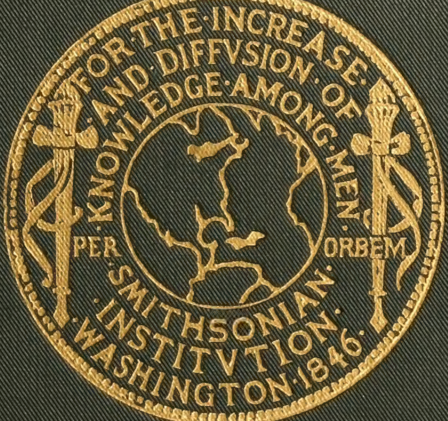
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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 100
VOLUME 2

CONTRIBUTIONS TO THE BIOLOGY OF THE PHILIPPINE ARCHIPELAGO AND ADJACENT REGIONS

PAPERS ON COLLECTIONS GATHERED BY THE "ALBATROSS" PHILIPPINE EXPEDITION 1907–1910

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The scientific publications of the National Museum include two series, known, respectively, as *Proceedings* and *Bulletin*.

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The present work forms No. 100, Volume 2, of the *Bulletin* series.

Alexander Wetmore,
Assistant Secretary, Smithsonian Institution.

Washington, D. C., September 11, 1931.

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By Maynard M. Metcalf, with the assistance of Mary M. Bell

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PYROSOMA: A TAXONOMIC STUDY BASED UPON THE COLLECTIONS OF THE UNITED STATES BUREAU OF FISHERIES AND THE UNITED STATES NATIONAL MUSEUM

By Maynard M. Metcalf and Hoyt S. Hopkins

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THE SALPIDAE COLLECTED BY THE UNITED STATES FISHERIES STEAMER "ALBATROSS," IN PHILIPPINE WATERS, DURING THE YEARS 1908 AND 1909.

By MAYNARD M. METCALF,
Of the Orchard Laboratory, Oberlin, Ohio.

The collections of Salpidae, made by the United States Fisheries steamer *Albatross* in Philippine waters, which were submitted to me for study, are in 98 lots from 60 stations and contain 11 species and 1 new variety.

The list is as follows:

Salpa (*Cyclosalpa*) *pinnata* FORSKÅL (1775), one individual of the aggregated form from Station D 5456, east of Southern Luzon, June 9, 1909.

Salpa (*Cyclosalpa*) *bakeri* RITTER (1905), aggregated form, from Station D 5437, between Bohol and Leyte, north of Mindanao, May 7, 1908, three specimens.

Salpa (*Ritteria*) *amboinensis* APSTEIN (1904), solitary form, from Station D 5530, Mindanao Sea, August 11, 1909.

Salpa cylindrica CUVIER (1804), solitary and aggregated forms, from six stations, as follows: D 5102, north of Manila Bay, January 6, 1908; D 5128, Sulu Sea, west of Negros, February 4, 1908; D 5155, southwestern end of Sulu Archipelago, February 19, 1908; D 5456, east of the southern end of Luzon, June 7, 1909.

Salpa fusiformis CUVIER (1804), solitary and aggregated forms, from seven stations, as follows: D 5120, south of Manilla Bay, January 21, 1908; D 5128, Sulu Sea, west of Negros, February 4, 1908; D 5223, at the eastern end of the passage between Luzon and Mindanao, April 24, 1908; D 5437, off the west coast of Luzon, May 8, 1908; D 5456, east of southern Luzon, June 7, 1909; D 5457, east of southern Luzon, June 8, 1909; D 5601, Molucca Passage, east of the north end of Celebes, November 7, 1909.

Salpa maxima FORSKÅL (1775), solitary and aggregated forms, from eight stations, as follows: D 5155, D 5162, and D 5166, all at the southwestern end of the Sulu Archipelago, February 19 to 24, 1908; "Jolo Anchorage," southwestern Sulu Archipelago, March 5, 1908;

D 5186, Sulu Sea, west of Negros, March 30, 1908; D 5456 and D 5458, Pacific Ocean, off the east coast of southern Luzon, June 7 and 8, 1909; D 5669, Macassar Strait, west of Celebes, December 29, 1909.

Salpa maxima, variety *tuberculata* (new), aggregated form, Station D 5200, Mindanao Sea, southwest of Bohol, April 9, 1908.

Salpa (*Ritteria*) *hexagona* Quoy and Gaimard (1824), solitary and aggregated forms, from 11 stations, as follows: D 5128, February 4, 1908, and D 5186, March 30, 1908, both stations in the Sulu Sea, west of Negros; D 5175, north central Sulu Sea, March 8, 1908; D 5196, east of Cebu, April 3, 1908; D 5234, between Leyte and Bohol, May 7, 1908; D 5237, Pacific Ocean, east of Mindanao, May 12, 1908; D 5350, China Sea, west of Palawan, December 27, 1908; D 5437, China Sea, west of Luzon, May 8, 1909; D 5530, Mindanao Sea, east of the southern end of Cebu, August 11, 1909; D 5601 Molucca Passage, east of the northern end of Celebes, November 7, 1909; D 5616, Molucca Passage, west of Gilolo, November 22, 1909.

Salpa (*Iasis*) *zonaria* Pallas (1774), solitary and aggregated forms, from 10 stations, as follows: D 5175, north central Sulu Sea, March 8, 1908; D 5186, Sulu Sea, west of Negros, March 30, 1908; D 5402, between Cebu and Leyte, March 16, 1909; D 5456, Pacific Ocean, off the southern end of Luzon, June 7, 1909; D 5500 and D 5530, Mindanao Sea, August 4 and 11, 1909; D 5601, Molucca Passage, east of the north end of Celebes, November 7, 1909; D 5632, south of Gilolo, December 2, 1909; D 5669 and D 5672, Macassar Strait, December 29 and 30, 1909.

Salpa (*Thetys*) *vagina* Tilesius (1802), solitary form, from three stations, as follows: D 5242 and D 5243, Pacific Ocean, off the east coast of Mindanao, May 14 and 15, 1908; D 5441, China Sea, off the west coast of Luzon, May 10, 1909.

Salpa (*Thalia*) *democratica* Forskål (1775), solitary and aggregated forms, from eight stations, as follows: D 5128, Sulu Sea, west of Negros, February 4, 1908; D 5166, southwestern end of Sulu Archipelago, February 24, 1908; D 5195 and D 5196, off east coast of Cebu, April 3, 1908; an unnumbered station off "Nogas Point, Panay," February 3, 1908; D 5233, Surigao Sea, south of Leyte, May 7, 1908; D 5456, east of the southern end of Luzon, June 7, 1909; D 5588, east coast of northern Borneo, September 28, 1909.

Salpa (*Pegea*) *confoederata* Forskål (1775), solitary and aggregated forms, from 21 stations, as follows: D 5140, D 5144, and three other stations, all near Jolo, central Sulu Archipelago, February 8, 10, 14, and 15, 1908; D 5196 and D 5232, east coast of Cebu, April 3 and 7, 1908; D 5224, east of Mindoro, May 7, 1908; D 5238, Pacific Ocean, off the east coast of Mindanao, May 12, 1908; D 5320, China Sea, between Luzon and Formosa, November 6, 1908; D 5456, east coast of southern Luzon, June 7, 1909; D 5530 and D 5540, northwestern Mindanao Sea, August 11 and 19, 1909; D 5553, D 5561, D 5578, and another station, all in the central and southwestern Sulu Archipelago, September 18, 19, 20, and 23, 1909; D 5604, Gulf of Tomini, Celebes, November 15, 1909; D 5616, Molucca Passage, November 22, 1909; D 5640, southeast coast of Celebes, December 13, 1909; D 5663, west of southern Celebes, December 28, 1909.

Salpa bakeri is discussed in the accompanying paper, "The Salpidae," and need be mentioned here only to say that it is a form somewhat similar to, though clearly distinct from *Salpa floridana* APSTEIN (1894, *b*). The three specimens in the *Albatross* collections are nearly adult, though still attached to one another. They are more nearly adult than any specimens of the aggregated form of this species heretofore seen.

Both the echinate form (*aspera*) and the smooth form of *Salpa fusiformis* are represented.

For a description of the new variety, *Salpa maxima tuberculata*, and of the rare and hitherto insufficiently-described *Salpa* (*Ritteria*) *amboinensis*, see the accompanying paper on "The Salpidae."

Nothing in the distribution of the species collected is very unexpected. The Salpas are purely pelagic and are likely to be carried at the will of the ocean currents. With the exception of a few species, their home is the warmer seas or the warmer currents of northern and southern seas. Those species which have thus far been reported from only a few localities are scarce forms. Their discovery is probably to be expected in time in other seas. Even the Mediterranean species have all been reported from other waters also.[1] The absence of *Salpa affinis* from these collections, and the rarity of *S. pinnata* where both might have been expected, and the presence of a rare species of this subgenus, *S. bakeri*, are noteworthy. The observed range of *Salpa maxima* is extended, for it has not been reported before from the western Pacific. In most parts of the world *Salpa democratica* and *S. fusiformis* are the most frequent and the most abundant Salpas. It is evident that *Salpa confederata* was found in Philippine waters by the *Albatross* most frequently and most abundantly.

At 11 stations more than one species of Salpidae were found at the same time.

Station D 5125, Sulu Sea, west of Panay, *Salpa democratica*, solitary and aggregated forms, and *S. cylindrica*, solitary form.

Station D 5128, Sulu Sea, west of Negros, *Salpa hexagona*, aggregated form, *S. fusiformis*, solitary and aggregated forms, *S. demo-*

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[1] *Salpa polae* SIGL (1912), seems better classed as a variety of *S. pinnata* than as a distinct species. It has been known heretofore only from the Mediterranean Sea. The United States National Museum collections discussed in the accompanying paper, contain a specimen of this form from the Hawaiian Islands.

cratica, solitary and aggregated forms, *S. cylindrica*, solitary and aggregated forms, and *S. zonaria*, solitary and aggregated forms.

Station D 5155, southwestern Sulu Archipelago, *Salpa cylindrica*, solitary and aggregated forms, and *S. maxima*, solitary and aggregated forms.

Station D 5166, southwestern Sulu Archipelago, *Salpa democratica*, solitary form, and *S. maxima*, solitary form.

Station D 5175, north central Sulu Sea, *Salpa hexagona*, aggregated form, and *S. zonaria*, aggregated form.

Station D 5186, Sulu Sea, off Negros, *Salpa hexagona*, aggregated form, *S. zonaria*, solitary form, and *S. maxima*, aggregated form.

Station D 5196, between Cebu and Leyte, *Salpa hexagona*, aggregated form, *S. democratica*, solitary and aggregated forms, and *S. confederata*, aggregated form.

Station D 5437, off west coast of Luzon, *Salpa hexagona*, solitary form, *S. fusiformis*, solitary and aggregated forms, and *S. bakeri*, aggregated form.

Station D 5456, east of southern Luzon, *Salpa confederata*, solitary and aggregated forms, *S. cylindrica*, solitary and aggregated forms, *S. democratica*, solitary and aggregated forms, *S. fusiformis*, aggregated form, *S. maxima*, solitary and aggregated forms, *S. zonaria*, aggregated form, and *S. pinnata*, aggregated form.

Station D 5601, Gulf of Tomini, Celebes, *Salpa fusiformis*, solitary form, and *S. hexagona*, solitary form.

Station D 5616, Molucca Passage, *Salpa confederata*, aggregated form, *S. hexagona*, solitary form, and *S. cylindrica*, solitary form.

Other species of Salpidae, which have been reported from East Indian and western Pacific waters, and which probably occur in Philippine waters, are *S. retracta*, *S. floridana*, *S. picteti*, and *S. multitentaculata*. In addition, certain species reported from the Indian Ocean might naturally be expected to occur in Philippine seas. These are *Salpa virgula*, *S. affinis*, *Salpa longicauda*, *S. rostrata*, and *S. radiata*. Indeed no great surprise should be felt at finding any species of this family in any part of any ocean, except in polar waters, to which but few species seem to penetrate.

This manuscript was completed for the United States Bureau of Fisheries on July 10, 1915, and received for publication by the United States National Museum on February 21, 1917.

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THE SALPIDAE: A TAXONOMIC STUDY.

By Maynard M. Metcalf,
Of the Orchard Laboratory, Oberlin, Ohio.

With the Assistance of Mary M. Bell.[1]

In studying the interrelationships of the Salpidae, one finds the greatest significance attaching to three sets of organs—the gut, the nervous system, and the muscles, the symmetry or asymmetry of the body and its muscles being a somewhat distinct point worthy of considerable emphasis. Other features will occasionally be mentioned, but are of minor importance. In all of these particulars the solitary form is readily seen to be the more conservative, while the aggregated individuals diverge far more. This more plastic character of the aggregated form causes it to present a larger body of phenomena in which evidence of relationship may be seen. In studying the Salpidae we are fortunate in having in the life cycle of each species a conservative member, the solitary form, showing in larger measure ancestral traits, and a more divergent member, more sensitive to modern trends in the evolution of the family.

In most groups of animals the nervous system is found to be a conservative organ system, not liable to much modification from superficial influences. It is therefore, in general, one of the best sources of taxonomic evidence. In the Salpidae, on the other hand, some features of the nervous system are found to be quite inconstant. For instance, the number of the nerves radiating from the ganglion is found to be variable, the grouping of the fibers into nerves being different in different individuals, or even on the two sides, right and left, of the ganglion in the same individual. This inconstancy is probably connected with the fact that the nervous system of the Salpidae is secondarily simplified ("degenerate"). There are outgrowths from the ganglia of certain species, especially in the aggregated forms, and the character of these is constant within the species and of taxonomic significance.

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[1] This paper is written by Maynard M. Metcalf. He has had the assistance of Miss Bell in studying the anatomy of the *Cyclosalpae*, and *Traustedtia*, and all of the original drawings of these forms were made by her. Numerous other drawings, as noted in each instance, have been made by Mr. Hoyt S. Hopkins, usually after careful independent study, and I wish to acknowledge my indebtedness to him not only for the drawings, but also for his observations, which have checked up and have supplemented my own.

The form of the horseshoe-shaped eye is much the same in the solitary individuals of all species, therefore little taxonomic data is found here. In the solitary forms of several species there are accessory eyes, or accessory portions of the horseshoe-shaped eye, and the character of these should be considered. But it is in the aggregated forms that the eyes furnish the chief taxonomic evidence. This evidence will be emphasized in the present paper. I have studied the eyes of the solitary and aggregated forms of all species of Salpidae except *Brooksia rostrata*, *Apsteinia magalhanica*, *Ritteria retracta*, *R. picteti*, *R. amboinensis*, *Thalia longicauda*, and *Traustedtia*, in none of which have the eyes of the aggregated forms been adequately studied for any profitable comparisons, except in the case of *Traustedtia multitentaculata*, for which Traustedt (1893) and Dober (1912) give meager data, which, however, will be seen to be significant. Göppert (1892) has made very accurate studies of the eyes of five species. Redikorzeff (1905) carefully reviews the structure of the eyes of three species, and Dober (1912) makes casual mention of the eyes of a number of species, figuring surface views with little detail. Citations will be made from all these sources.

Accessory, smaller eyes are present in the aggregated forms of a number of species. The number, form, position and histological condition of these accessory eyes, as well as the form, position and histological condition of the chief eye, will furnish usable evidence.

Divergent as are the eyes in the several subgenera and species of Salpidae, their structure is constant within the species, and so furnishes an abundance of taxonomic evidence. This evidence is of especial value, because the changes that have occurred in the phylogeny of these eyes have been so largely degenerative rather than adaptive. Adaptive divergence and convergence can be left out of consideration in connection with these degenerating organs. Such changes as have occurred in these eyes in their recent phylogeny probably have been due to trends within each species and not to adaption to environment. The natural affinities of the species are therefore probably more clearly expressed than they could be were the freedom to change the structure of the eyes limited by relations of utility.

Reference to the chart on page 158 will show the classification of species which I have adopted, and it should be studied a few moments at this point, if my nomenclature is to be understood in the further reading of this paper. There seems little choice as to the purely academic question whether the subdivisions of the Salpidae given in this chart be taken as genera or subgenera. The argument from convenience would favor treating them as subgenera. Relationships are indicated with equal clearness according to either usage.

I have been fortunate in having for study, in addition to my own considerable collections, all the collections of Salpidae made by the

United States Bureau of Fisheries [1] since the year 1875, including extensive lots from the northern, the equatorial, and the southern Atlantic Ocean, from the Pacific Ocean off the South American and North American coasts, from the Hawaiian Islands, and from the Philippine Islands. In addition, I have received material of three species from the Naples Zoological Station. Through the courtesy of Prof. E. A. Andrews, of the Johns Hopkins University, I have received all of Prof. W. K. Brooks's collections of Salpidae, including the specimens of *Cyclosalpa floridana* from which he redescribed that rare species. Prof. W. E. Ritter, of the University of California, has also very kindly given me three good specimens of his *Cyclosalpa bakeri*, solitary individuals, one of which bears an old stolon, at the tip of which are well-formed individuals of the aggregated generation. From him I also received two wheels and a very large aggregated zoöid of *Cyclosalpa affinis* from the California coast. I wish to express my most hearty thanks for this material to Professor Ritter and Professor Andrews, to the United States Commissioner of Fisheries, and to the authorities of the United States National Museum, and I wish to acknowledge my indebtedness to the Naples Station for the privilege of purchasing their beautifully preserved material. I wish also to acknowledge with thanks the assistance given by the librarian of the United States National Museum in locating in the libraries of Washington and other cities some of the volumes in the literature of the Thalidae which are not easy to obtain.

Subgenus CYCLOSALPA (de Blainville), 1827.

Five species of this subgenus have been described:

Cyclosalpa pinnata FORSKÅL, 1775, *type.*[2]
C. affinis CHAMISSO, 1819.
C. floridana APSTEIN, 1894, *b* (not 1906, *b*).
C. bakeri RITTER, 1905.
C. virgula VOGT, 1854.

Sigl (1912, *a* and *b*) has described as a distinct species *Cyclosalpa polae*, a form which so closely resembles *C. pinnata* that it can best be treated as a subspecies of *pinnata*, much as *Salpa aspera* is classed as a form of *S. fusiformis* and *S. bicaudata* as a subspecies of *Pegea confederata*.[3]

Cyclosalpa pinnata is the best known of the Cyclosalpas, especially through Brooks' extensive studies. *Cyclosalpa affinis*, which has been carefully studied by Ritter and Johnson (1911), is a closely related species. Very different from these are *C. floridana*, named by Apstein (1894, *b*), and *C. bakeri*, described by Ritter (1905). *Cyclosalpa virgula* is the sole representative of still a third division of the subgenus. Ritter's (1906, *b*) *Cyclosalpa retracta*, of which only the solitary form is known, seems very similar to Apstein's (1904) *Salpa amboinensis*, and with this species and with *S. picteti* of Apstein (1904) and *S. hexagona* of Quoy and Gaimard (1824) it forms a natural group intermediate in some respects between the Cyclosalpas and those Salpidae which have the gut compacted into a so-called "nucleus." This group I am naming *Ritteria* after Professor Ritter, who described the species *retracta*.[1]

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[1] Chiefly by the United States Bureau of Fisheries steamer *Albatross*.

[2] The author prefers the Latin form of this word, *typus*, when used in the strictly taxonomic sense, but he defers to the custom of the United States National Museum in its publications.

[3] The character of the eye, as well as the presence of appendages, justifies recognizing *bicaudata* as a somewhat distinct form.

The three species *punctata*, *asymmetrica*, and *magalhanica*, which I have named *Apsteinia*, after *Apstein*, who first described two of this group,[2] agree with the Ritterias, so far as known, and with *Cyclosalpa bakeri*, *C. virgula*, and *Brooksia rostrata* in the asymmetry of their muscles in the aggregated forms, all but *Apsteinia punctata* showing also asymmetry in the shape of the body. Asymmetry is somewhat less marked in the higher members of the family, especially in *Thalia*, *Thetys*, *Pegea*, and *Traustedtia*.

The Cyclosalpas may be divided into two groups—the symmetrical forms, *Symmetricales*, including *C. pinnata*, *C. affinis*, and *C. floridana*, and the *Asymmetricales*, including C. *bakeri* and *C. virgula*. The asymmetry characterizes only the aggregated forms of these species and may be related to the manner of their arrangement upon the stolon. Well-developed stolons of *C. virgula* or *C. bakeri* have not been described. For *C. bakeri*, neither Ritter's (1905) description nor our specimens show any indication of the formation of whorls, though one of our stolons is very old with the zoöids apparently ready to drop off. Ritter writes: "As to the whorls of zoöids, it can only be said at present that the close similarity of this species to *Cyclosalpa affinis* and *C. pinnata* in the arrangement of the zoöids in the chain makes it highly probable that the whorls are likewise much the same in the two." In the *Albatross* Philippines collections were three individuals of the aggregated form of this species which were 12 mm. in length, three times as long as Ritter's and our specimens from the California coast. These three delicate collapsed individuals are united together, but not in any way indicative of either the presence or absence of whorl formation. The three symmetrical species of *Cyclosalpa* are well known to form distal whorls upon their stolons. We have no evidence that the Cyclosalpas with asymmetrical aggregated individuals do form such whorls, and one suspects that they do not and that the asymmetry of their aggregated individuals is correlated with the conditions of crowding in a biserial [3] stolon.

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[1] Ritter, 1906, *b*.

[2] Apstein (1894, *b*, and 1901).

[3] Of course pseudobiserial; really a uniserial chain with alternate links crowded out to opposite sides.

The Salpidae, other than the *Cyclosalpae*, none of them form whorls upon their stolons, and many of them show more or less marked asymmetry in the aggregated individuals. This asymmetry affects both the shape of the body and the arrangement of the muscles in the aggregated *Apsteinia asymmetrica* and *A. magalhancia*. It affects the arrangement of the muscles, but not the body form, in the globose *A. punctata*. It affects the shape of the body and somewhat the arrangement of the muscles, especially those of the base of the atrial siphon, in the aggregated forms of *Ritteria amboinensis* and *R. hexagona*, *Salpa maxima* and its variety *tuberculata*, *S. fusiformis* and its form *aspera*, and *Iasis zonaria*. The aggregated forms of *Salpa fusiformis* and *S. cylindrica* are really asymmetrical in the shape of the body and in the position of the atrial siphon and its sphincter muscles, though the asymmetry is less marked in these species. *Thalia*, *Thetys*, *Traustedtia*, and *Pegea* show little asymmetry. Possibly a detailed study of the attachment of the individuals in the stolon might throw light upon the absence of asymmetry in these species, but we have not undertaken the study.

CYCLOSALPA PINNATA[1] (Forskål) (1775).

Thalia No. 1 and No. 2, No. 3 (?), BROWNE, 1756.
Holothuria thalia LINNAEUS, 1758 [=Browne, *Thalia* No. 1].
H. caudata LINNAEUS, 1758 [=Browne, *Thalia* No. 2].
Salpa pinnata FORSKÅL, 1775.
S. cristata CUVIER, 1804.
S. caudata LAMARCK, 1813.
Dagysa [species not named] HOME, 1814.
Salpa thalia LAMARCK, 1816.
S. cyanea DELLE CHIAJE, 1828.
S. proboscidialis LESSON, 1830.
Cyclosalpa pinnata HERDMAN, 1888.

Cyclosalpa pinnata is in some regards the most primitive of the Salpidae. Its body muscles have a hoop-like arrangement in the solitary form (pl. 1, fig. 1), and are interrupted both dorsally and ventrally in the median plane. To those who believe with Brooks that the Salps are descended from Doliolum-like ancestors, the regular hoop-like arrangement of the muscles would seem primitive and their dorsal and ventral interruption secondary. Their regularity of arrangement seems almost surely primitive.

The bilateral symmetry of the aggregated zoöids in this species, and in the other *Cyclosalpae symmetricales*, might at first thought seem another archaic feature, but the accuracy of this suggestion depends perhaps upon whether the habit of forming whorls of zoöids upon the stolon is primitive or secondary, for, as already noted, the asymmetry observed in so many of the Salpidae may be due to crowding in a biserial stolon. I see no sufficient evidence that the cyclic grouping of the zoöids upon the stolon is more archaic than the biserial arrangement, except the fact that it occurs in those species which for other reasons we regard as the most primitive.

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[1] The identification of Browne's "*Thalia* No. 1" and "*Thalia* No. 2" as *Cyclosalpa pinnata*, solitary and aggregated forms, seems in all probability correct. However, as the identification is not beyond question, it does not seem best to displace the long established species name *pinnata*, substituting the name *thalia* which Linnaeus gave, following Browne.

We have even in *Cyclosalpa pinnata* an interesting bit of asymmetry in the larger eyes of the aggregated individuals, which Metcalf[1] has mentioned. "Göppert[2] points out that in *Salpa maxima*, in individuals from the right side of the chain, the long axis of the eye is directed obliquely toward the right, while in individuals from the left side of the chain the eye points toward the left. This gives importance to a slight though constant peculiarity I have observed in the otherwise symmetrical eye of the chain *Cyclosalpa pinnata*, which serves to determine the relation of the animal to the stolon. In this group the individuals stand with both their antero-posterior and dorso-ventral axes at right angles to the [young] stolon. In the large dorsal eye of each individual, on the side distal from the former attached end of the stolon, there is a small unpigmented spot in the midst of the pigment area of the second region of the eye." This minute asymmetrical feature is related to the position of the zoöid in the at first biserial stolon. Only when the individuals have reached their adult form do they assume the whorl grouping. Even in *Cyclosalpa pinnata*, therefore, we find a trace of asymmetry in the aggregated form, and this is found to be correlated with the position of the zoöids in the stolon in its earlier stages, before the whorls are formed and while the arrangement is that of a double series of individuals, as in the stolons of all the Salpidae except the *Cyclosalpae symmetricales*. This suggests that the habit of forming whorls at the tip of the stolon in the *Cyclosalpae symmetricales* is secondary.

It is in the anatomy and development of the eyes in the aggregated form that we find the clearest evidence of the relatively archaic character of *Cyclosalpa pinnata*. One familiar with the condition of the eyes in the several species of Salpidae could hardly believe that they show an ascending series culminating in the elaborate and histologically perfect eye of *Cyclosalpa pinnata*, though in my first papers upon this subject I took this position, which now seems to me so untenable.[3] We seem clearly to be dealing with a series of increasingly degenerate forms, so far as the structure of the eyes is concerned. This degeneration goes so far that in its most extreme condition one doubts the functional value of the organs affected. Such an imperfect and possibly functionless eye as we find at its worst could hardly be regarded as the starting point of an ascending series of increasingly developed eyes. The character of the rod cells in the imperfect eyes of the more aberrant Salpidae seems clearly to indicate degeneration. A typical rod cell from any well-developed Salpa eye would be about as shown in figure 1. Compare this with a group of rod cells from, say, *Pegea confederata* (fig. 2). In the former the glassy modification of the protoplasm, which constitutes the "rod" (represented in black in the figures), is regular and is found at one end of the cell, as is characteristic of the rod cells of the eyes of vertebrates, of Amphioxus, of the ascidian tadpole, and of most invertebrates. On the other hand, in those species of Salpidae whose eyes I would consider degenerate, the rod cells are very irregular in shape, are irregularly crowded into masses instead of being arranged as a regular epithelium, and each rod cell has the protoplasm usually of its whole periphery converted into the typical glassy substance, this glassy layer being of different thickness in different rod cells and in different portions of the same cell.

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[1] Metcalf (1893, c), p. 370.

[2] Göppert (1892).

[3] Lest it be thought that I may have been influenced in this former conclusion by my teacher, Prof. W. K. Brooks, I would say that at the time of my writing the former papers he demurred from this opinion.

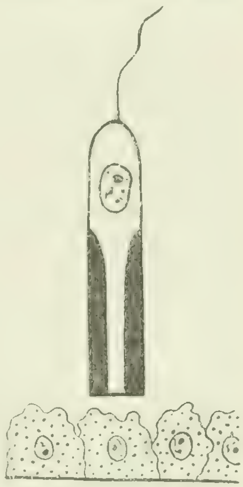

FIG. 1.—A SCHEMATIC REPRESENTATION OF A SINGLE ROD CELL AND FOUR PIGMENT CELLS FROM THE EYE OF A SALPA. FROM METCALF (1893, *c*).

Taking, then, as our starting point *Cyclosalpa pinnata*, which, from the arrangement of its muscles and the structure of its eyes, seems one of the two most primitive of the species of Salpidae, let us note its general structure, giving attention to a few new features we have discovered. Then let us briefly review the anatomy and development of its eyes, as already described by Metcalf (1893, *c*). Having refreshed our memories of the salient features in this species, we can proceed to comparisons with other species.

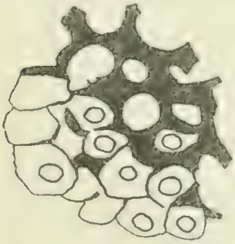

FIG. 2.—PEGEA CONFEDERATA, A GROUP OF ROD CELLS FROM THE DORSAL EYE OF THE AGGREGATED ZOÖID. OBSERVE THEIR IRREGULARITY OF FORM AND THE IRREGULARITY OF FORM AND THE UNEQUAL THICKENING OF THEIR CELL WALLS. ×340 DIAMETERS.

Cyclosalpa pinnata is represented in the collections of the United States National Museum by the following catalogue numbers:

Cat. No. 6460, U.S.N.M. (solitary form) from Naples Zoological Station; two specimens.

Cat. No. 6461, U. S. N. M. (aggregated form) from Naples Zoological Station; nine specimens, united.

Cat. No. 6553, U.S.N.M. (aggregated form), *Albatross* station D, 5456, east coast of Luzon, San Bernardino Strait, to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature 86° F.; one specimen.

CYCLOSALPA PINNATA, solitary form.[1]

Plate 1, figs. 1 and 2; plate 2, fig. 6.

Referring to figure 1, which shows the solitary form of *Cyclosalpa pinnata* as seen from the right side, observe the general shape of the body, keg-shaped, with the anterior end rather abruptly narrowed and the posterior end more tapering. The test is delicate and thin, being thickest ventrally. The luminous organs are seen halfway up each side of the body, as a series of five spindle-shaped glands between the body muscles. In structure they resemble blood lacunae full of blood corpuscles, and such may have been their derivation, though now their cells are modified, each containing numerous yellow granules of a substance which by oxidation produces light. The luminous organs of *Pyrosoma* are very similar histologically.

The ribbon-shaped muscles are shown in figure 1. For convenience of description these may be divided, chiefly according to function, into body muscles (indicated by Roman numerals), oral muscles, and atrial muscles. There is also another muscle which in the more primitive Salpidae is associated with the body muscles but in the more modified species is more connected with the oral muscles. This is usually called by German zoölogists the "Bogenmuskel." We will refer to it as the intermediate muscle (*i. m.* in the figures).

Of the *body muscles* there are seven, as numbered in the figure. They are arranged like the hoops of a keg, but each is interrupted on the mid line both dorsally and ventrally. The intermediate muscle is continuous ventrally with its fellow of the other side, as are the lip muscles. It probably shares with the oral muscles the function of strengthening the lower lip which acts as a valve to close the mouth when the water is expelled throught the atrial aperture by the contraction of the body muscles (fig. 6).

Most prominent of the oral muscles are the horizontal *oral retractors*, one on each side, running forward from the first body muscle to the angle of the mouth (fig. 1). Anteriorly each divides into two muscles, *oral sphincters*, which run around the lower lip, one near the edge (*l. 1*), the second a little farther back (*l. 2*). The anterior two sphincter muscles of the upper lip (*u. 1* and *u. 2*) are almost but not quite united to the retractor at their ventral ends. In addition to the oral retractor just described and the sphincters united to or acting in conjunction with it, there is on each side a more *ventral oral retractor*, running from lower down on the first body muscle diagonally forward and upward, passing outside of the intermediate muscle, to a point a little posterior to the place of branching of the dorsal oral retractor. The ventral retractor is here internal to the dorsal retractor. At the point where the two retractors are at the same level, the ventral retractor divides, giving rise to a ventral branch, which forms the third sphincter of the lower lip (*l. 3*), and to a wider dorsal branch which after a very short course divides to form the third (*u. 3*) and fourth (*u. 4*) sphincters of the upper lip,. We may describe the oral muscles as made up of two retractor systems, one consisting of the dorsal retractor and the anterior two sphincters of each lip, the second consisting of the ventral retractor, the third sphincter of the lower lip and the third and fourth sphincters of the dorsal lip. Well up on the side of the fourth sphincter of the dorsal lip there arises a muscle band, the dorsal horizontal muscle, which runs backward and dorsal-ward to unite with the dorsal end of the intermediate muscle, the fused muscle continuing its course postero-dorsally to a point at the side of the ganglion.

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[1] The drawings and descriptions are based on studies of abundant material of both solitary and aggregated forms of this species, chiefly from the central Mediterranean Sea and off the Atlantic coast of North America. Compare United States National Museum Collections, Cat. No. 6460.

The *atrial muscles* in the solitary form of this species consist only of a series of sphincters which are complete hoops. The anterior atrial sphincter is a strong band and may function with the body muscles in expelling water from the body, but its position, well out on the base of the atrial siphon, and its complete hooplike character, make it natural to assign it to the atrial series. The adjacent sphincter is peculiar in the fact that its ventral portion bends forward, runs across the basal sphincter on the inside and crosses the ventral line well toward the last body muscle, at the level of the posterior ends of the two intestinal caeca. A higher development of a somewhat similar arrangement in the solitary form of *Cyclosalpa virgula* (pl. 11, fig. 26) gives the diagonal course of the ventral end of this muscle an atrial retractor effect. In *Cyclosalpa pinnata* this effect is hardly secured. The rest of the atrial sphincters are very delicate. They branch and the branches from one sphincter unite with other sphincters, forming a slight irregular network.

The relative strength of the several muscles is correlated with the amount of work they do. The strong body muscles, by vigorous contraction, expel the water from the pharyngeo-atrial chamber within the body. Those who have observed living Salps, describe this contraction as ejecting water with considerable violence, throwing the whole Salpa forward a considerable distance. The oral sphincters have to resist the pressure of this water, preventing it from flowing out through the mouth. They are so much weaker than the combined strength of the whole series of body muscles that they would be unable successfully to resist the pressure of water caused by the contraction of the body muscles, were it not that the oral sphincters are aided by a valve device, to be described in the next paragraph. The atrial sphincters are for the most part very delicate and able to perform little labor, but their function is merely to close the atrial aperture during diastole of the body. The enlarging of the body after contraction is due to the elasticity of the test, which in this species is very delicate. When once the atrial pore is closed, the suction due to the enlarging of the body will tend to keep it closed. Very slightly developed sphincters therefore are enough. It is important to have a series of sphincters instead of a single one at the edge of the atrial siphon. If only the edge of the aperture closed, leaving the rest of the siphon widely open, the tip would be introverted, and then even a strong sphincter at the edge of the aperture could hardly prevent water entering the body through the atrial pore. But the narrowing or complete closing of the whole atrial siphon avoids any danger of such introversion. The heavier sphincter muscle at the base of the atrial siphon probably aids in preventing the siphon as a whole from becoming introverted.

Reference was made in the previous paragraph to the *valve* action of the lower lip. The structural conditions bringing about this effect are shown in figure 6, plate 2, a dorso-lateral-anterior view of the mouth region of the solitary *Cyclosalpa pinnata*. The lower lip is turned inward, forming a deep rounded pouch. The edge of the lip is a thin irregular flap. At the base of the flap are the two admarginal sphincter muscles. Further ventral is the third sphincter, which serves to support the bulging middle portion of the pouch, while the admarginal sphincters cause a stronger contraction of the inturned portion of the lip, giving the pouch form to the whole lower lip. The backward pull of the dorsal oral retractor goes directly to the inturned portion of the lower lip, so that this is very strongly inturned. The contraction of the dorsal lip muscles, of the dorsal retractor system, brings the upper lip down into contact with the lower lip. The thin flap at the inturned edge of the lower lip lies against the inside of the contracted upper lip, serving effectively to prevent any egress of the water. The ventral retractor, with its two dorsal sphincters and one ventral sphincter, strengthen and support both lips. The actual closing effect, however, is due chiefly to the dorsal retractor system.

The positions of the gill, dorsal tubercle, endostyle, and peripharyngeal bands are sufficiently indicated in figure 1. The form of the aperture of the dorsal tubercle is shown in figure 2.

The *alimentary canal* consists of the huge pharynx (imperfectly demarcated by the gill from the atrium), the esophagus, intestine, and two caeca. No well-marked stomach is found. The flaring trumpet-shaped esophageal aperture lies at the ventral end of the gill, the ciliated cells of the gill being continued into the esophagus into which they constantly carry a stream of mucus and entangled food particles. As in *Pyrosoma*, there is a line of cilia from the esophageal aperture to the posterior end of the endostyle, where it is continuous with the lateral ciliated bands of the endostyle. The direction of the currents caused by these cilia is not known. (For a drawing of this line of cilia in another species see figure 38, page 65.) The narrow esophagus curves to the right, then to the left, and is continued into the intestine. The curve of the gut is therefore a left-hand curve as in the Ascidians. The first portion of the intestine is somewhat enlarged, and might possibly be called the stomach, but in reality there is no demarcated stomach. The intestine is straight. It stretches along the dorsal side of the whole length of the gill, the anal opening leading into the atrium, just back of the ganglion. At the place where the esophagus joins the intestine two caeca arise. These turn backward, lying one on each side of the mid line. The position of the anal aperture in this species, far forward in the body, should not be seriously disadvantageous, for it is behind the gill, and there should be little danger of clogging the cilia currents of the gill with the fecal wastes.

The *heart* lies on the mid-ventral line a short distance in front of the esophageal aperture, between the fifth and sixth body muscles, in connection with a slight evagination of the mid-ventral surface of the mantle.

The *stolon* arises in front of the heart, on the mid-ventral line, and runs forward in the median plane. As shown by Brooks (1886), it is at first a single series of buds lying each with its ventral surface toward the free tip of the stolon. Later the alternate links of this chain become crowded out to opposite sides of the stolon, forming a pseudobiserial chain of buds. At the tip of the stolon, whorls of from 5[1] to 15[2] individuals are formed. None of our specimens show more than two whorls, one fully formed, the other beginning to assume the radial arrangement.

Opposite the intermediate muscles and near the median line are two languet-like protuberances of the mantle (*v. l.*, fig. 1), one on each side, extending into the test and nearly to its outer surface. Streiff (1908) has shown these in his figures. They are present also in *Cyclosalpa bakeri*. They suggest comparison with the more numerous and more developed mantle protuberances in *Thalia* and *Traustedtia*.

The spheroidal ganglion and nerves need no description here. Above the ganglion, and resting upon it, is a horseshoe-shaped *eye* with the ends of the horseshoe toward the front (fig. 3). Over the lateral and posterior portions of the eye runs the continuous layer of pigment cells (fig. 4). Dorsally these are just beneath the ectodermal epithelium: more ventrally they lie in the midst of the cells of the optic ridge: but in all regions they lie inside the continuous limiting membrane of the eye and ganglion. Along the whole inner side of the horseshoe are the elongated rod-cells with their thin-walled ends directed toward the center of the horseshoe, while their rods are directed toward the pigment layer. Between the rods and the pigment cells is a layer of intermediate cells. The innervation of the rod-cells has not been found by any observer in the solitary form of any species.

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[1] Sigl, 1912, *a* and *b*.

[2] Our specimens from Naples.

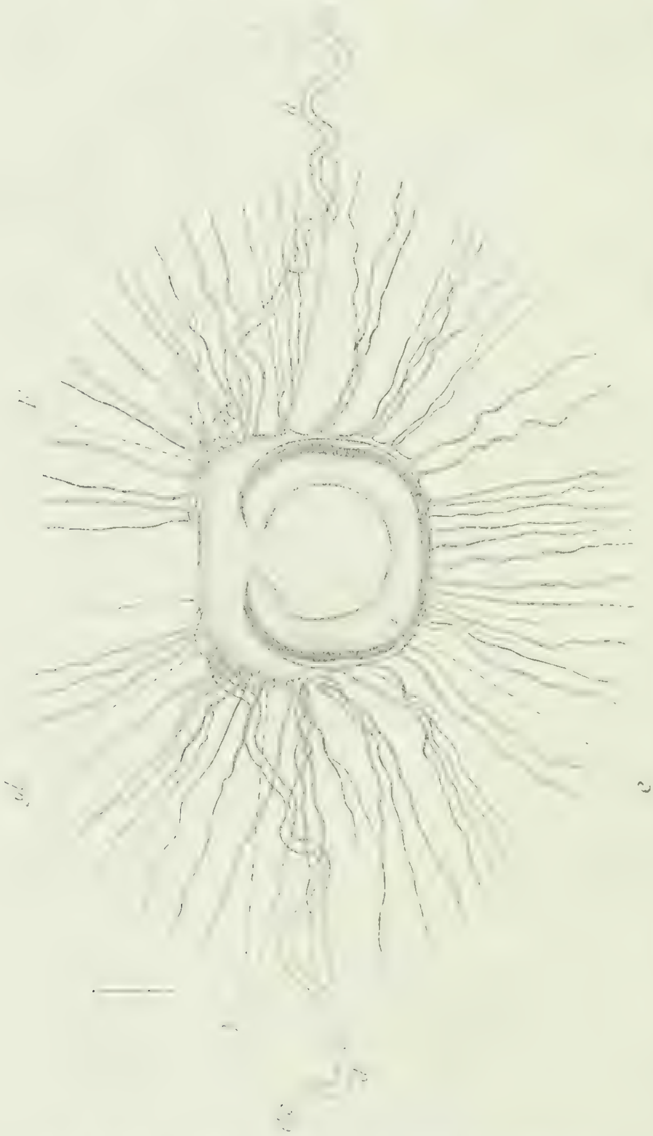

FIG. 3.—CYCLOSALPA PINNATA, SOLITARY FORM, DORSAL VIEW OF THE EYE, GANGLION, AND NERVES. THE DISKS OF THE NEURAL GLAND (*gl.*) SHOW A LITTLE BELOW THE GANGLION, AND THE LARGE-CELLED (*b'*) AND SMALL-CELLED (*b*) OUTGROWTHS FROM THE GANGLION CAN ALSO BE SEEN. × 107 DIAMETERS. FOR EXPLANATION OF THE INDEX LETTERS FOR THIS AND ALL OTHER TEXT FIGURES. SEE THE "(EXPLANATION OF TEXT FIGURES AND PLATES" AT THE END OF THIS PAPER.

It is necessary to refer briefly to the embryonic development of this eye. Early in its development the central nervous system of the embryo is a short hollow tube opening in front through a funnel. Later the walls of the posterior portion of the tube thicken, first ventrally, then dorsally (fig. 5), to form the ganglion, the lumen of the tube becoming obliterated. At the same time the anterior por-

FIG. 4.—CYCLOSALPA PINNATA, SOLITARY FORM. A TRANSVERSE SECTION OF THE GANGLION AND THE EYE. × 150 DIAMETERS. FROM METCALF (1893, *c*).

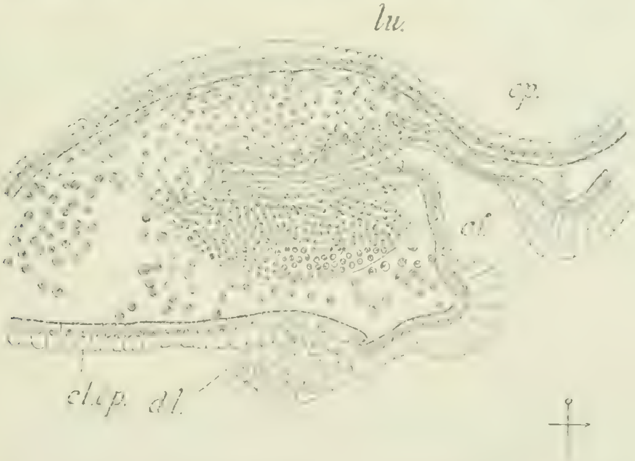

FIG. 5.—CYCLOSALPA PINNATA, EMBRYO, A SAGITTAL SECTION OF THE DEVELOPING GANGLION AND CILIATED FUNNEL. × 180 DIAMETERS. FROM METCALF (1893, c).

tion of the tube degenerates, the funnel becoming entirely separated from the ganglion. The funnel becomes the dorsal tubercle. The central cells of the ganglion degenerate and their place is taken by a feltwork of fibers, which in section has a punctate appearance. As the central cells are degenerating, the dorsal cells of the ganglion are increasing in number, and some of them are pushing up to form a ridge, in the shape of a horseshoe, in which later the histological differentiation occurs which gives the adult condition of the eye. The rudiment of the eye is, from the first, horseshoe-shaped and it continues in this form (fig. 6).

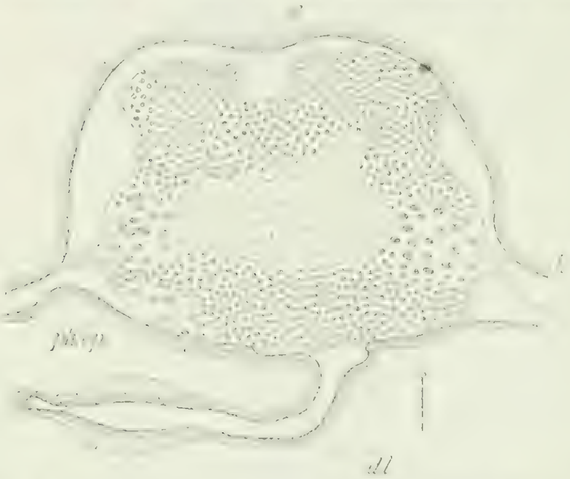

FIG. 6.—CYCLOSALPA PINNATA, EMBRYO, A TRANSVERSE SECTION OF THE DEVELOPING GANGLION AND EYE. × 150 DIAMETERS. FROM METCALF (1893, *c*).

But one other set of structures needs mention in this description—the *neural glands* and the outgrowths from the ganglion which are connected with them. Ventral to the ganglion, on the right and on the left, is a flattened horizontal chamber opening to the atrium by a long slender and much coiled duct (figs. 7 and 8. See also fig. 71, which shows the similar, though larger, disks and ducts in the aggregated zoöids of *Salpa maxima*). The walls of the chamber and of its duct consist throughout of a single layer of epithelial cells. These are the structures which Dober (1912) and others have called otocysts. I know of no indication of otocystic function (Metcalf, 1893, *c* and

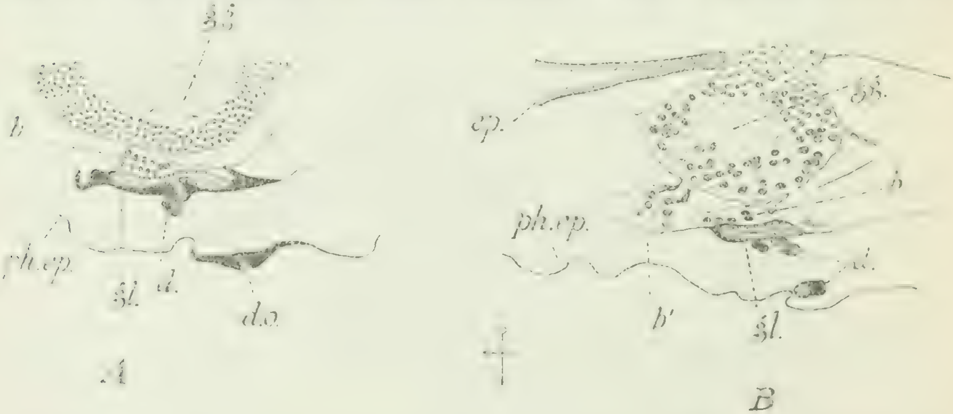

FIG. 7.—CYCLOSALPA PINNATA, AGGREGATED FORM, PARASAGITTAL SECTIONS THROUGH THE GANGLION, ONE NEURAL GLAND, AND THE OUTGROWTHS FROM THE GANGLION; FROM A DEVELOPING ZOÖID. × 139 DIAMETERS. FROM METCALF (1893, *c*).

1899). In some other species they are clearly glandular, forming the secretion by proliferation of cells from the epithelium and their degeneration.

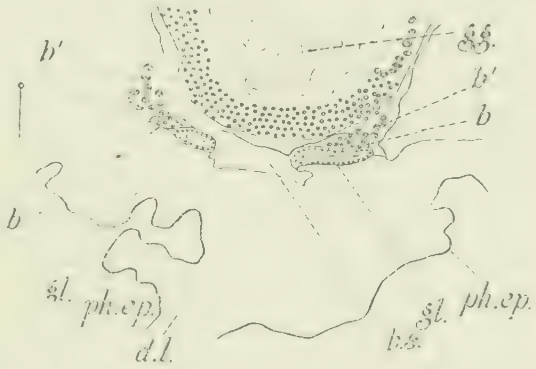

FIG. 8.—CYCLOSALPA PINNATA, AGGREGATED FORM, A TRANSVERSE SECTION THROUGH THE VENTRAL HALF OF THE GANGLION, THE NEURAL GLANDS, AND THE OUTGROWTHS FROM THE GANGLION. × 130 DIAMETERS. FROM METCALF (1893, *c*).

In the Salpidae the neutral glands arise from the epithelium of the pharyngeo-atrial chamber, in a manner described by Metcalf (1892, 1893, *b* and *c*). This is entirely different from the neural gland of Ascidians and Pyrosoma, which arises from the wall of the neural tube. The gland in Ascidians and Pyrosoma opens into the dorsal tubercle by a duct which is the persistent anterior end of the nerve tube. In the Salpidae the neural glands have never at any time any connection with the dorsal tubercle or the nerve tube, its ducts, like the glands themselves, coming from the epithelium of the pharyngeo-atrial cavity. There seems, at first thought, no ground for any homology between the neural glands in Salpidae and the neural glands of other Tunicates, and we have no fully convincing reason for believing their functions to be the same. But common function and true homology between the glands of Salpa and the gland of Ascidians is suggested by the conditions in *Ascidia mammillata* and some of its nearest relatives, in which the very slender and greatly elongated duct leading from the neural gland to the ciliated funnel[1] is much branched laterally, these branches connecting with the pharynx by small ciliated funnel-shaped pores. In these forms, the neural gland opens to the pharynx by the ciliated funnel proper and also by very numerous lateral pores.[2] In other Ascidians the neural gland opens only by way of the ciliated funnel. Embryonic Salpas and young buds have the neural tube opening forward into the ciliated funnel, but they have no neural gland. Later the neural tube closes and its connection with the ciliated funnel is lost. Then a new type of neural gland, as described, developes from the pharyngeo-atrial epithelium. This may have arisen ancestrally from structures like the lateral ducts and pores of the neural gland in *Ascidia mammillata* and its relatives. In *Octacnemus*, which Herdman (1888) has placed among the Salpidae, I found the neural gland to be wholly of the Ascidian type. This is one of several features in its structure that have led me to count

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[1] This is really the anterior end of the nerve tube.

[2] See Metcalf (1900), section 1.

Octacnemus as an aberrant offshoot from the primitive Ascidians, whose nearest extant relatives are the Clavelinidae.[1] To this classification Ritter (1906, *a*) has given his approval, and Herdman (1904) has recently expressed his agreement.

Above the neural gland, on each side, are two outgrowths from the ganglion, one of small cells continuous with the smaller cells of the ganglion itself (fig. 8, *b*), the other a mass of large cells (*b′*) like the larger cells of the ganglion. Both these masses of cells arise as outgrowths from the ganglion. The small-celled group retains its continuity with the ganglion. The large-celled group, on the other hand, is distinct from the ganglion, but is connected with it by numerous well-developed nerve fibres.

Many have studied the solitary form of *Cyclosalpa pinnata*. There are some discrepancies, for the most part slight, between our work and that of others, but it seems hardly well to burden this paper with a detailed discussion of these discrepancies. It is doubtful just how far the differences in description may be taken as indicating variation in structure in the species, and to what extent allowance must be made for the personal equation of the observers. In our observation of many specimens from the Atlantic Ocean and from the Mediterranean Sea we have found the structure uniform as we describe it. The very careful work of Streiff upon the muscles agrees with our observations, except in two minor regards. He does not show contact between the fourth oral sphincter muscle of the dorsal lip and the horizontal band which runs up and back to join the dorsal portion of the intermediate muscle. In other species we have found divergence in the near approach or actual connection of such accessory muscle bands, and we do not doubt the accuracy of Streiff's description. He does not show the diagonal second atrial sphincter which we have described as showing a rudimentary atrial retractor arrangement. We find no other authors' figures sufficiently accurate in detail for profitable comparison of this point. All our specimens show the condition which we figure.

CYCLOSALPA PINNATA, aggregated form.[2]

Plate 1, figs. 3 and 4; plate 2, figs. 5, 7, and 8.

The aggregated form of *Cyclosalpa pinnata* is shown in figure 3, which gives a view from the right side. One observes the presence of a stalk of attachment, or peduncle, by which the individual was joined with the other zoöids into a whorl. Postero-ventrally the visceral region of the body is bulged out, the single intestinal caecum pushing out into a slight evagination of the mantle, suggesting comparison with the visceral protuberance ("post-abdomen" of Ritter) seen in *Cyclosalpa floridana* (pl. 5, fig. 15), *C. bakeri* (pl. 8, fig. 21), and *C. virgula* (pl. 12, fig. 29). The lower lip is inrolled to function as a valve, much as in the solitary form. This valvular action of the lower lip is characteristic of all species of Salpidae, both solitary and aggregated forms, and need not be mentioned in the reference to other species unless it shows some feature of special interest.

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[1] See Metcalf (1900), p. 579.

[2] United States National Museum Collection. Cat. No. 5181.

The *test* in the aggregated form is thicker than that of the solitary form, but is no less soft. The luminous organ is a single large gland on each side in the interval between the second and third body muscles.

There are four body *muscles* (I to IV). There is but a single oral retractor, with which are united the three sphincter muscles of the lower lip (*l. 1*, *l. 2*, *l. 3*). The first sphincter of the upper lip (*u. 1*) is almost, but not quite, continuous with the retractor. The second and third sphincters of the dorsal lip (*u. 2* and *u. 3*) are united to the intermediate muscle. There is no ventral oral retractor such as is found in the solitary form. The absence of this ventral retractor accounts probably for the difference in the insertion of the third sphincter of the lower lip (*l. 3*), which in the solitary individual belongs to the ventral retractor system, but in the aggregated individual is attached to the single retractor here present. The intermediate muscle (*i. m.*) bends backward at its dorsal end and unites with the upper portion of the first body muscle. There is an approach, but no union, of these muscles in the solitary form. The body muscles are much less regularly arranged in the aggregated form than in the solitary individuals. All are continuous dorsally across the mid line. Ventrally, as in the solitary form, the intermediate muscle is in contact with its fellow of the opposite side, but it is not continuous across the mid line. Each is continued ventrally into the peduncle. In young zoöids these anterior peduncle muscles are distinct except that they touch at their tips. In older zoöids they are closely appressed from their tips in the peduncle almost up to the mid-ventral line of the body. The intermediate muscles are therefore distinct, though at first glance in an older zoöid they appear united ventrally.

The aggregated individual differs from the solitary in having the last body muscle continuous ventrally with its fellow of the other side. The fused muscle (*v.*) turns forward on the mid line and runs a short distance toward, but not to, the gut. Figure 3 is slightly distorted, showing this part of the muscle as a flat band, rather than a line as it should appear in edge view.

We find in the aggregated form of this species a muscle not before described, lying on the mid-ventral line, beneath the intestine (*v.'*) We have again distorted our figure to show this *visceral muscle* as a broad band instead of as a line which would be its true appearance in side view. Posteriorly the visceral muscle seems to be connected with the funnel-shaped group of connective tissue fibers whose apex is near the ventral end of the last body muscle. These connective tissue fibers probably establish a functional connection between the ventral end of the last body muscle and the visceral muscle, so that their contraction probably produces much the same effect that would be secured if they were actually continuous. The last body muscle is similarly continued into the visceral region in *Cyclosalpa affinis* (pl. 3, fig. 10) *C. floridana* (pl. 5, fig. 15), and *C. bakeri* (pl. 8, fig. 22). None of these, however, shows a separate visceral muscle. There is nothing comparable in *C. virgula* (pls. 11, 12, and 13).

The intermediate muscles, which in older zoöids are in contact ventrally, are continued as a strong double muscle through the peduncle almost to the stolon (or core of the whorl). On each side of the body the first body muscle unites with the third to form a broad band of muscle, which is similarly continued through the peduncle toward the core of the whorl, but it is not prolonged so far into the peduncle as are the intermediate muscles. There is one of these posterior peduncle muscles on each side. They are entirely independent of each other.

The sphincter muscles of the atrial siphon are unbranched. Each is a complete hoop. The first is a strong muscle and is connected with the last body muscle by a horizontal band which functions as an atrial retractor.

The gill is as in the solitary form. The outline of the aperture of the dorsal tubercle is shown in figure 4 (pl. 1). No comment is needed upon the endostyle and peripharygeal bands.

The *gut* of the aggregated form differs from that of the solitary form in the presence of but one caecum and in the ventral position of the intestine, below the endostyle, the anus being well forward toward the front of the pharynx. It would seem that this position for the anus would be very disadvantageous, discharging feces in such a manner that they would become entangled in that current of mucus which by action of the cilia is constantly being carried forward on the endostyle, up on the peripharyngeal bands and back on the gill to the esophageal aperture.

The *heart* (*h.*) lies to the right of the intestine, a little higher up than in the solitary form.

The *ovary* is in front of the fourth body muscle, the oviduct leading forward almost to the third body muscle. The elongated *testis* lies between the endostyle and gut (pl. 2, fig. 5 *t.*). Its duct opens near the anus, as in other Cyclosalpas, but in this species the position of both apertures is further forward than in any other aggregated form in the Salpidae.

The ganglion is flattened on its dorsal surface where lies the large *eye* (pl. 2, figs. 7 and 8). The ganglion contains two pairs of minute hemispherical eyes, each of which is composed of about 25 rod cells (fig. 9, p. 23). The posterior pair lie one on side each of the middle point of the posterior face of the ganglion (*cy*). These have no pigment. The thin-walled ends of the rod cells lie outward in the eye and toward the surface of the ganglion. The dorsal pair of minute eyes lie one below the base of each limb of the horseshoe-shaped larger eye, on the dorsal surface of the ganglion (*cr*). The rod ends of their rod cells are turned toward the surface of the ganglion, immediately below the pigment of the larger eye. No innervation has been found for any of the small eyes within the ganglion of this or other species of Salpidae. In some species pigment is found associated with them.

Projecting forward from the middle of the dorsal surface of the ganglion is a large horseshoe-shaped eye nearly equal in bulk to the whole ganglion (pl. 2, figs. 7–8). The middle of the curve of the horseshoe and its two ends are thick; the sides are slender. Behind and a little above the curved portion of the eye is a laterally elongated plug of optic cells, lying above the space which intervenes between the two limbs of the horseshoe. The figures show, without much description, the structure of this large eye. Figure 8 (pl. 2) is a dorsal view and figure 7 (pl. 2) a view from the right side of the eye and ganglion. Figure 9, above, shows a parasagittal section and indicates also the position of the minute eyes in the ganglion. Figure 10, page 24, is from a transverse section of the posterior limbs of the horseshoe. Figure 1, page 11, is a diagrammatic drawing of one rod cell and a few pigment cells. One readily sees in figure 9, above, the innervation of the rod cells of the limbs of the horseshoe and of the plug, but no one has yet shown for the adult the innervation of the rod cells in the arch of the horseshoe. In the nearly mature eye, however, I have shown[1] nerve fibers passing down between the limbs of the horseshoe to innervate

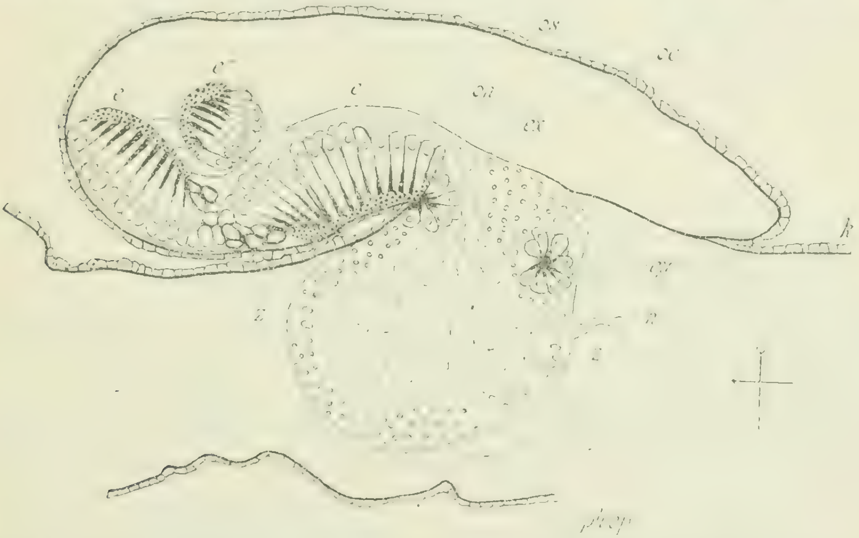

FIG. 9.—CYCLOSALPA PINNATA, AGGREGATED ZOÖID, A PARASAGITTAL SECTION THROUGH THE GANGLION, THE ACCESSORY EYES OF THE LEFT HALF OF THE GANGLION, AND THE LEFT LIMB OF THE DORSAL EYE. THE FIGURE REPRESENTS THREE SECTIONS COMBINED. × 150 DIAMETERS.

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[1] Metcalf, 1893, *c. cf.*, plate 48, figure 9, *o. n''*.

the ventral thin-walled ends of the rod cells of the arch of the horseshoe. There are no intermediate cells between the rods and the pigment cells in the eyes of the aggregated *Cyclosalpa pinnata*. Such intermediate cells are present in the eye of the solitary form. In the aggregated zoöids of *C. pinnata*, as in those of all other species whose eyes have been studied, the pigment cells are superficial. In the solitary *C. pinnata* they lie deeper among the cells of the optic ridge.

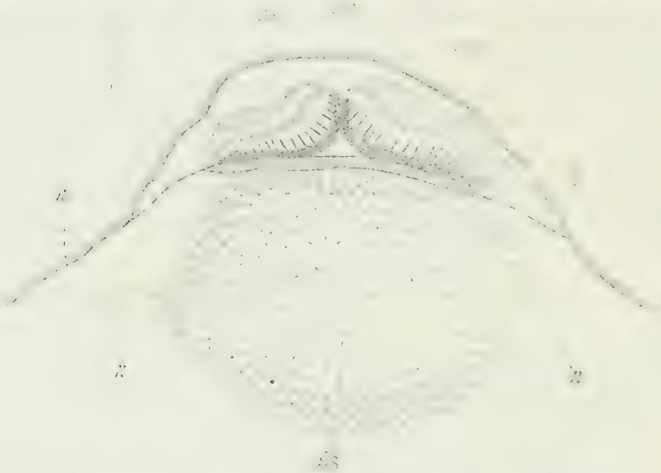

FIG. 10.—CYCLOSALPA PINNATA, AGGREGATED ZOÖID, A TRANSVERSE SECTION THROUGH THE GANGLION AND THE TWO POSTERIOR LIMBS OF THE DORSAL EYE. × 150 DIAMETERS. FROM METCALF (1893, c).

Göppert (1892) has shown the presence of ovoid phaeosphaeres in the rod cells of the large eyes of the aggregated forms of *Cyclosalpa pinnata* and *Pegea confederata*, also in the eye of the solitary *Salpa maxima*. I have not succeeded in demonstrating these, but doubtless careful work upon better preserved material would show them. One can not doubt the accuracy of Göppert's studies.

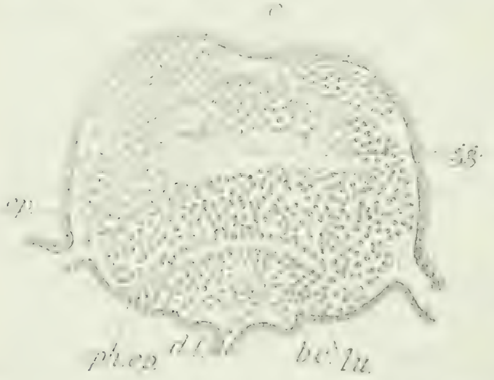

FIG. 11.—CYCLOSALPA PINNATA, AGGREGATED FORM, A TRANSVERSE SECTION OF THE DEVELOPING EYE. THE TWO ANTERIOR LIMBS (*c*) OF THE AT THIS STAGE HORSESHOE-SHAPED EYE ARE SHOWN. × 200 DIAMETERS. FROM METCALF (1893, *c*).

The development of the large eye of the aggregated *Cyclosalpa pinnata* must also be described, as it is an important aid to understanding the taxonomic value of the comparative anatomy of the eyes of the aggregated forms of the several species of Salpidae. When first discernible the rudiment of the eye is exactly similar to that in a young embryo of the solitary *Cyclosalpa pinnata*, a horseshoe-shaped ridge of cells, above the ganglion, with the ends of the horseshoe anterior (fig. 11). The simple horseshoe shape of the eye of the solitary form is doubtless therefore primitive. This is also indicated by the fact that in the solitary forms of all Salpidae the eye has this horseshoe form.

In later stages of development of the aggregated zoöid, the arch of the horseshoe separates from the ganglion (fig. 12) and rises up, the whole rudiment of the eye swinging at first upward then forward and downward, the two ends of the horseshoe remaining attached to the dorsal surface of the ganglion and forming the pivots upon which the eye rotates. By this rotation the originally ventral surface of the rudiment of the eye becomes first posterior then dorsal. Three other changes occur in the developing eye during the gradual completion of this forward rotation. First the space between the limbs of the horseshoe-shaped optic ridge becomes nearly filled by proliferated

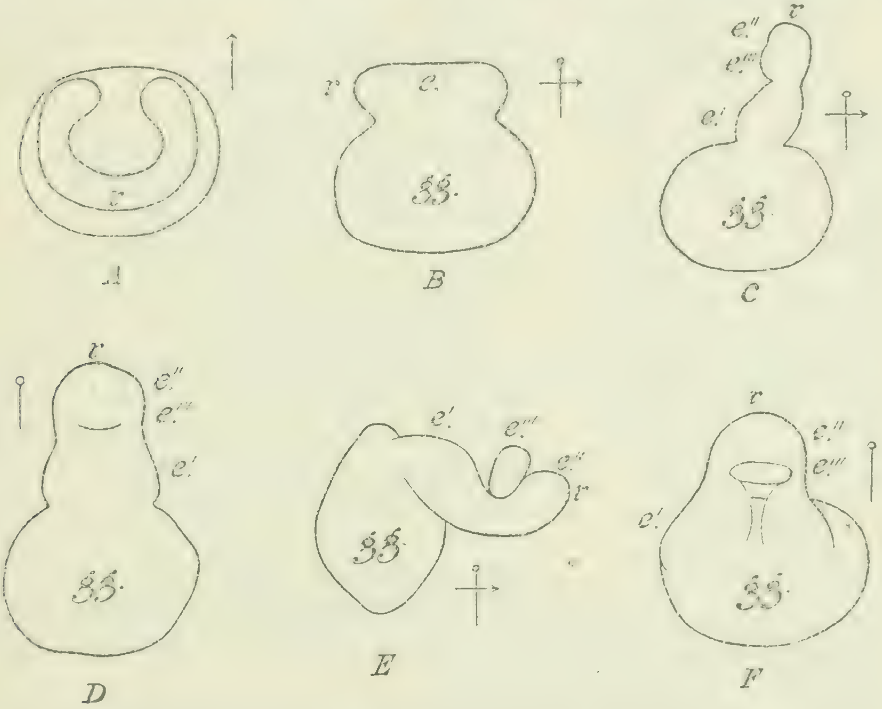

Fig. 12.—Cyclosalpa pinnata, aggregated zoöid, diagrams showing the forward rotation and transformation in shape of the dorsal eye. From Metcalf and Johnson (1905); *e*, eye; *gg*, ganglion; *r* indicates in each case the same region of the eye.

A, A dorsal view of the ganglion and the eye of a solitary salpa. The horseshoe-shaped eye is above the ganglion, with the ends of the horseshoe pointing forward. The dorsal eye of the very young aggregated zoöid has the same form.

B, The same seen from the right side.

C, The ganglion and the eye of an immature aggregated zoöid. The eye has now rotated forward and upward through an arc of about 90°. That surface of the eye which was dorsal when the eye was horizontal (*B*) is now anterior.

D, The same eye and ganglion as in *C*, but viewed from behind. The eye is in the form of a flat plate, the hollow of the horseshoe having become filled with cells.

E, The eye and ganglion of an adult seen from the right side. The eye has shifted 90° still further forward and is again horizontal, but with its former posterior portion anterior and its former dorsal surface ventral.

F, Dorsal view of the same ganglion and eye as in *E*. The eye is now split posteriorly into two limbs, right and left, being again horseshoe-shaped.

cells (fig. 12, *D*). Later these gather again into the limbs of the horseshoe, which become enlarged and entirely distinct from each other (*F*). The third change is the formation of the plug of optic cells, which arises by the tip of the arch of the horseshoe curling over backward (fig. 12, *C*) and later becoming the almost independent mass of cells figured (*E*, *F*, and pl. 2, figs. 7 and 8). For more adequate description of the structure and development of the ganglion and eyes of *Cyclosalpa pinnata* see Metcalf (1893, *c*).

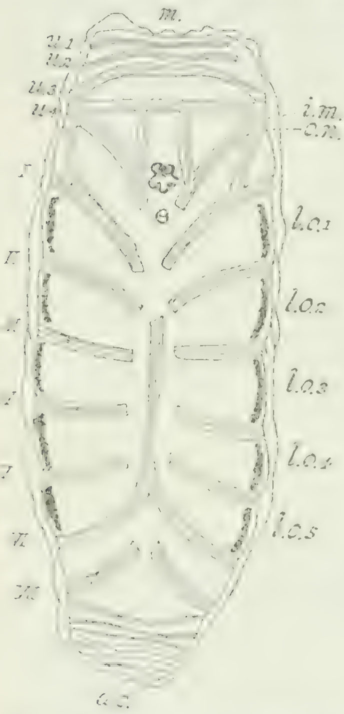

FIG. 13.—CYCLOSALPA PINNATA, SUBSPECIES POLAE, SOLITARY FORM, DORSAL VIEW. FROM SIGL (1912, *a*).

The neural glands are similar in the solitary and aggregated forms.

CYCLOSALPA PINNATA, subspecies POLAE (Sigl) (1912).

Cyclosalpa polae SIGL (1912).

This subspecies is said by Sigl to be distinguished by two features: first, in the solitary individuals, the fusion of body muscles VI on the dorsal mid line and their continuance forward as a median muscle band reaching almost to the level of body muscles II (fig. 13); and, second, the long peduncle by which the aggregated zoöids are united to form the wheel (fig. 14).

In the collections of the United States National Museum submitted to us are three specimens of the solitary *Cyclosalpa pinnata* which are of the subspecies *polae*. One is 17 mm. long; one is 7 mm. long; the third is an embryo 8 mm. long, in which the placenta is present. None of them show any peculiarity beyond the presence of the median dorsal extension of body muscles VI. In the same bottle, and of course from the same place of collection, is another solitary individual 24 mm. long, of the usual *pinnata* character. There are also 8 aggregated zoöids 14 mm. long, four of them still attached together in a broken wheel, and 2 aggregated zoöids 11 mm. long, not attached.

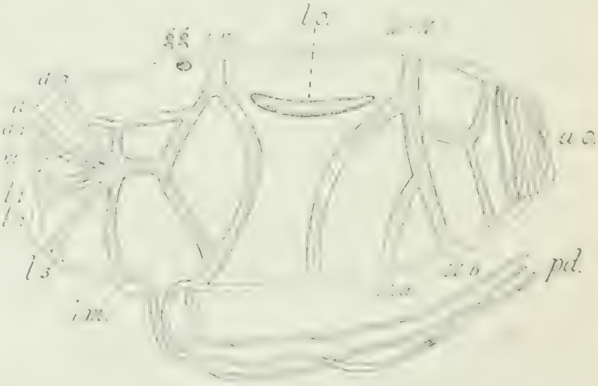

FIG. 14.—CYCLOSALPA PINNATA, SUBSPECIES POLAE, AGGREGATED ZOÖID VIEWED FROM THE SIDE. FROM SIGL (1912, *a*).

None of the aggregated zoöids show unusually long peduncles. In none of the solitary individuals is the stolon sufficiently developed to show buds, and the embryos in the aggregated zoöids are much too young to show muscles. These specimens bear the label Cat. No. 6432, U.S.N.M. (solitary form) *Albatross* station D 3901, Mokuhooniki Islet, Pailolo Channel between Maui and Molokai Islands, Hawaiian Islands, April 29, 1902; surface; surface temperature 74° F.; 10+ specimens.

CYCLOSALPA AFFINIS (Chamisso, 1819).

Plate 3 and plate 4, figs. 11 and 12.

Salpa affinis CHAMMISSO, 1819 (*type*).
C. affinis de BLAINVILLE, 1827.
C. affinis HERDMAN, 1888.
C. chamissonis BROOKS, 1893.

The following specimens of *Cyclosalpa affinis* are in the collections of the United States National Museum:

Cat. No. 6450, U.S.N.M. (solitary form) *Albatross* station D 2585, off Cape May; Sept. 19, 1885; 542 fathoms; surface temperature 73° F; one specimen.

Cat. No. 6451, U.S.N.M. (embryo) *Albatross* station 2749, south of Block Island, Sept. 19, 1887; 705 fathoms; surface temperature 67° F.; one specimen.

Cat. No. 2833 U.S.N.M. (aggregated form) *Albatross* station D 2587, off Cape May; Sept. 20, 1885; 326 fathoms; eight specimens.

Cyclosalpa affinis most resembles *C. pinnata* and is apparently its nearest relative. In the solitary form the resemblance in shape of body and character of test is close. *Cyclosalpa affinis* has no luminous organs in either the solitary or aggregated forms. Only in *Cyclosalpa pinnata* are luminous organs present in the aggregated form. They are found in the solitary forms of *C. pinnata*, *C. floridana*, *C. bakeri*, and *C. virgula*, that is, in all species of *Cyclosalpa* except *C. affinis* One naturally guesses that the depths in the ocean to which the several species penetrate may be correlated with the presence or absence of luminous organs, but we have little data for testing this surmise. The greatest depths at which *Cyclosalpae* are certainly known to have been taken are 55 meters (*C. pinnata* Ihle, 1910) and 500 meters (*C. pinnata*, subspecies *polae* Sigl 1912, *b*). Hauls with the vertical net, collecting everything from the greater depths to the surface, have sometimes contained Cyclosalpas, but we have no knowledge of the horizontal strata from which the examples were taken. Nor have we any data indicating that in *Cyclosalpa floridana*, *C. bakeri*, and *C. virgula* the solitary forms penetrate to greater depths than the aggregated forms. Observations upon the vertical distribution of the Cyclosalpas are to be desired. Since among the Cyclosalpas luminous organs are found in the conservative solitary form of several species and in the aggregated form of only one species, we may judge that the possession of luminous organs was an ancestral character which most Salpidae have lost. The presence of luminous organs in *Pyrosoma* is in line with this suggestion.

In the solitary *Cyclosalpa affinis* there are seven hooplike body muscles, as in *C. pinnata* (pl. 3, fig. 9). The intermediate muscle is interrupted dorsally and complete ventrally (=*C. pinnata*). The first and second body muscles are interrupted both dorsally and ventrally (=*C. pinnata*). The rest of the body muscles are all interrupted ventrally (=*C. pinnata*), but they are continuous dorsally across the mid line.

The oral retractor muscle is divided horizontally to form two retractors, each continued forward into a sphincter muscle of the lower lip. The upper of these two sphincters is admarginal and aids in the incurving of the valve-like lower lip. The more ventral of the two sphincters supports the bulge of the pocket valve which the lower lip forms. There are but two sphincter muscles in the lower lip. The anterior two sphincters of the upper lip are as in the solitary *Cyclosalpa pinnata*. The third and fourth unite at their ventral ends and lie internal to the oral retractors, just in front of the point where the intermediate muscle passes inside them. The third and fourth sphincters of the upper lip are not in actual connection with either the retractors[1] or the intermediate muscle.[2] As in the solitary *C. pinnata*, there is in the solitary *C. affinis* a longitudinal band of muscle running diagonally upward from the fourth sphincter of the upper lip to the upper end of the intermediate muscle. It does not, however, come into as intimate union with either muscle as in *C. pinnata*. The atrial sphincters are quite similar to those in the solitary *C. pinnata*, but the atrial retractors are better developed, being connected posteriorly to two rather strong sphincters.

The gut resembles that of the solitary *Cyclosalpa pinnata* in position and form except that there is but one caecum, apparently median.

The heart lies below the esophagus, in a considerable evagination of the ventral wall of the body.

Our specimens of the solitary form of this species have the zoöids on the stolon but slightly developed and do not show any whorls. After Ritter and Johnson's (1911) careful study of the stolon of this species there is no need of discussion of this structure from our material.

The outline of the aperture of the dorsal tubercle is shown in figure 12 of plate 4.

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[1] In the solitary *Cyclosalpa pinnata* they connect with the ventral retractor.

[2] In the aggregated *C. pinnata* probably similar muscles connect with the intermediate muscle.

There are no languet-like protuberances opposite the ventral portions of the intermediate muscles, as in *Cyclosalpa pinnata*, but there are a pair of minute papillae, one on each side of the atrial opening. These were of larger size in the individual figured by Ritter and Johnson. Their internal structure suggests comparison with the tubular outgrowths of the mantle and test, which in *Thalia*, and especially in *Traustedtia*, are so much more developed.

The ganglion and its ventrolateral outgrowths, the neural glands and the eye resemble those of the solitary *Cyclosalpa pinnata* too closely to need description.

CYCLOSALPA AFFINIS, aggregated form.[1]

Plate 3, fig. 10; plate 4, figs. 11 and 12.

The aggregated form of *Cyclosalpa affinis* again presents evidence of close relationship between this species and *C. pinnata*, though there are some differences from the aggregated individuals of the latter species. The test is very much thicker, especially dorsally and ventrally, but it is as soft. The body muscles are the same in number, but in *C. affinis* the bands are more nearly parallel, i. e., body muscles I and II do not touch dorsally or ventrally and III and IV do not so closely approach dorsally. The body muscles in both species are continuous across the mid line dorsally, while ventrally all are interrupted except the posterior branch of the last.

The condition in the peduncle muscles, in the intermediate muscles, and in the last body muscles at their ventral ends need comparison with their condition in the aggregated *Cyclosalpa pinnata*. In *C. affinis* the ventral portions of the intermediate muscles approach and touch on the mid-ventral line of the body. They continue ventrally as full width bands closely appressed to each other for a short distance into the peduncle, their tips again separating slightly. It is therefore evident that the anterior peduncle muscle in this species is double, as in *C. pinnata*.

In *Cyclosalpa pinnata* the first and second body muscle on each side unite to form one of the pair of posterior peduncle muscles. In *C. affinis* the posterior peduncle muscles are distinct from all the body muscles. They do not closely approach either the first or second body muscle. They do bend back and approach near to the third body muscles on each side, somewhat above the mid line, but they do not unite. The slight protuberance from the front of the peduncle in figure 10 is probably without significance. It is not found in many individuals.

The ventral ends of the posterior branches of the fourth body muscle (IV, *a*) unite and continue into the visceral evagination (post-abdomen of Ritter) as a single broad band (*v.*) comparable probably to the slightly developed tip of the fused ends of the fourth body muscles in *Cyclosalpa pinnata* plus the visceral muscle which in *C. pinnata* is not continuous with this. The fourth body muscle on each side, near its ventral end, branches, giving rise to a small band which runs back into the visceral region (postabdomen).

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[1] United States National Museum collections. Cat. No. 6449.

The atrial retractor and sphincter systems, in the two species *Cyclosalpa affinis* and *C. pinnata*, are similar except in two minor points: first, in *C. affinis* the atrial retractor connects with the posterior branch of the fourth body muscle instead of connecting above its point of branching; and, second, the delicate sphincters branch form a slight network.

The gut differs in position and structure from that of the aggregated *Cyclosalpa pinnata*. It is in the form of a wide loop, the anal aperture being at the left of the esophagus, instead of far forward below the endostyle. There is a more marked stomach-like enlargement of the gut in this species. No caecum is present. The gut seems to be approaching the condition observed in the true *Salpae, sensu strictu*, in its curved form (though it is not yet a "nucleus"), in the absence of a caecum, and in the presence of a slight stomach enlargement. An intestinal gland is present, its duct stretching from its aperture into the stomach, across the empty space of the loop, the branches of the gland itself being along the distal half of the intestine. The crowded condition in *Cyclosalpa pinnata*, caused by the close approximation of the intestine, endostyle, and testis, makes the intestinal gland difficult to observe in that species.

The testis lies along the intestine as in *Cyclosalpa pinnata*, but the looped condition of the intestine allows it more space and it is a little more stocky. The vas deferens opens near the esophageal aperture. The ovary is in a position similar to that which it occupies in *Cyclosalpa pinnata*. The heart lies beneath the posterior end of the endostyle, in a slight ventral protuberance of the body.

The outline of the aperture of the dorsal tubercle is shown in figure 12, plate 4. The ganglion and its ventro-lateral outgrowths and the neural gland are so similar to those of the aggregated *Cyclosalpa pinnata* as to need no description. The large eye, on the other hand, shows a few significant divergencies from that of the aggregated *Cyclosalpa pinnata*. Its long axis points not horizontally forward as in *C. pinnata*, but forward and fifteen degrees upward (pl. 4, fig. 11). The rotation of the developing eye has not gone so far as in *C. pinnata*. The plug of optic cells is smaller than in the latter species and is less distinct from the arch of the horseshoe. The posterior portion of the eye is not divided into two swollen limbs, but is continuous from side to side and is thinner than are the limbs of the eye in *C. pinnata* (fig. 15, this page). This recalls the condition of the developing eye of *C. pinnata* during the early part of its rotation (fig. 12, D, p. 25). The position of the eye and the undivided condition of its posterior portion, also the less developed state of the plug in the adult *Cyclosalpa affinis*, parallel features of the immature eye of *C. pinnata*. Shall we interpret this as indicating that *C. affinis* is more archaic than *C. pinnata*, or as showing it already to have begun those retrogressive changes which culminate in the decided degeneration of the eye in the more modified species of Salpidae? The approach in the condition of the intestine to that of the true *Salpae*, a secondary feature, makes one inclined to interpret the divergence in the eye as secondary, a slight degeneration, consisting of an inhibition of some of the later phases of the development. On the other hand, the more regular character of the muscles in the aggregated *Cyclosalpa affinis* is doubtless more archaic than the condition in *C. pinnata*.[1] The evidence from the muscles and that from the gut are therefore opposed. Our studies have inclined us to give weight to the latter and to interpret the comparative anatomy of the eyes accordingly.

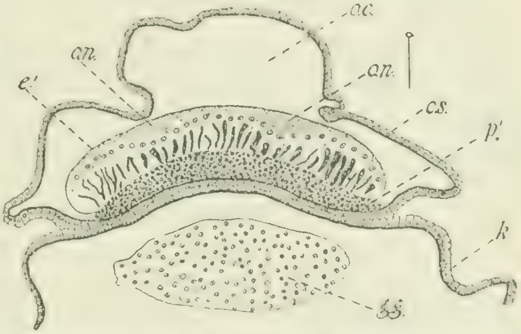

FIG. 15.—CYCLOSALPA AFFINIS, AGGREGATED ZOÖID, A CROSS SECTION OF THE POSTERIOR PORTION OF THE DORSAL EYE. × 150 DIAMETERS. FROM METCALF (1893, *c*).

The two pairs of smaller eyes in the ganglion of the aggregated *Cyclosalpa affinis* are similar to those in the chain form of *C. pinnata*.

Our figures and description of *Cyclosalpa affinis* are based upon the study of two specimens of the solitary form, one from an unnamed locality, the other from the Atlantic Ocean, off the mouth of Delaware Bay, in latitude 38° 24′ north and longitude 71° 17′ west [U. S. Bureau of Fisheries station 2717]; of three embryos 11 mm. and 14 mm. long, from the Atlantic Ocean, south of the eastern end of Long Island, in latitude 39° 42′ north and longitude 71° 17′ west [U. S. Bureau of Fisheries station 2749]; and of many specimens of the aggregated form from the Atlantic coast of North America, from Cape Hatteras to Cape Cod, and from the Pacific Ocean, off the California coast, the station not being more exactly stated. We have numerous others, embryos, but have not given them careful study.

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[1] I have not followed the development of the body muscles in embryos or buds of *Cyclosalpa affinis* or *Cyclosalpa pinnata*. In the development of the aggregated zoöids of *Thalia democratica*, one sees that the body muscles arise first as regularly spaced hoops, and their dorsal approximation into two groups, as seen in the adult, occurs late in the development. This confirms the opinion that regular hoop-like arrangement of the body muscles is archaic.

The chief studies of *Cyclosalpa affinis* have been made by Ritter (1905) and by Ritter and Johnson (1911). A few minor discrepancies between their work and ours will be noticed as to the lip muscles, the branching of the atrial sphincters, and the presence of an atrial retractor; also they fail to describe the muscles of the peduncle. Brooks has shown the latter in his figures (Brooks, 1893, pl. 8), but not as we have indicated them. We find them as we show them in specimens from both the Atlantic and Pacific coasts of America.

CYCLOSALPA FLORIDANA (Apstein, 1894, b, not 1906, a).

Cyclosalpa dolichosoma-virgula Traustedt, 1893 (according to Apstein, 1894, *b*).
Salpa floridana Apstein, 1894, *b*, (*type*).
Cyclosalpa floridana Ihle, 1910.

This, the most aberrant of the *Cyclosalpae symmetricales*, has its nearest relative apparently in *C. bakeri*, one of the two species composing the *Cyclosalpae asymmetricales*, but we shall compare it first with the two species already discussed.

CYCLOSALPA FLORIDANA, solitary form.

Plate 4, figs. 13 and 14; plate 5, fig. 16.

Our figures and description are based on the study of three specimens 16 mm. long, the same upon which Brooks (1908) worked. These are from Nassau in the Bahama Islands and were collected in May and June, 1907. Specimens of this form are in the United States National Museum. Cat. No. 6452, U.S.N.M. (solitary form) *Albatross* station D 2585; off Cape May; Sept. 19, 1885; 542 fathoms; surface temperature, 73° F.; one specimen.

The form of the body, the thickness of the test, and the general arrangement of the viscera and muscles are seen in figure 13, a view from the left side. The luminous organs are a series of five weakly-developed glands similar to those of *Cyclosalpa pinnata*, but not composed of nearly so many cells. Their position is similar in the two species. The group of cells between body muscles I and II is but about a third as long as one of the next three groups. The fifth group, behind body muscle V, is so slightly developed as hardly to be discernible.

There are seven body muscles, as we group them. These are all interrupted dorsally, as in *Cyclosalpa pinnata*. Ventrally each is continuous with its fellow across the mid line, except muscle VI, which is interrupted. In the solitary form of both *C. pinnata* and *C. affinis* all of the body muscles are interrupted ventrally. The first, second, third, and fourth body muscles approach each other ventrally, fusing into a common mass. The dorsal ends of the body muscles converge more than in the other *Cyclosalpae symmetricales.* The intermediate muscle is continuous ventrally but interrupted dorsally.

At first glance the oral muscles seem to show a pattern similar to that of *Cyclosalpa pinnata,* but closer observation shows the details of their relations to be quite different. The figure needs some description. The dorsal retractor is seen to divide into four bands, the lower or fourth of which passes forward into the lower lip to form what at first glance seems to be the first sphincter of the lip, but it is really the third sphincter. The lower lip is very strongly inturned, so that its first and second sphincter muscles appear in side view to lie behind the third sphincter. The upper branch of the dorsal retractor forms the first or admarginal sphincter of the strongly-incurled lower lip. The second branch of the retractor forms the second sphincter of the lower lip. The third branch of the retractor passes up outside the first and second branches to form the second sphincter of the upper lip. The first sphincter of the upper lip arises by one or two branches on each side from the second sphincter of the lower lip. (Compare with solitary and chain forms of *Cyclosalpa bakeri.*) The third and fourth sphincters of the upper lip unite below into the ventral retractor which, as in *C. pinnata,* passes inside the dorsal oral retractor and outside the intermediate muscle, diagonally downward and backward, to unite with the first body muscle, near its ventral end. The dorsal connection of the fourth sphincter of the upper lip with the intermediate muscle is as in *Cyclosalpa pinnata,* though the former is more prolonged posterodorsally. Note that the third sphincter muscle of the lower lip in the solitary *C. floridana* is a branch of the dorsal oral retractor, as in the aggregated *C. pinnata*, *C. bakeri*, and *C. virgula,* while in the solitary *C. pinnata* and *C. bakeri* it is a branch of the ventral oral retractor.

The muscles of the atrial siphon differ slightly from those of either *Cyclosalpa pinnata* or *C. affinis.* There are fewer, but three, delicate sphincters, all of which are unbranched. There are two stronger basal sphincters, also unbranched, and there is a well-developed diagonal atrial retractor which continues ventrally as far forward as the last body muscle.

The gut (see also fig. 14) shows the usual trumpet-shaped esophageal opening and an excessively curved esophagus which opens into a small right caecum near its origin from the intestine. The straight intestine lies, as in the solitary forms of all the Cyclosalpas, along the dorsal side of the gill. The left caecum is noticeably larger than the right and lies further from the mid line.

The stolon in our specimens is curled to the right, differing from the straight ventral stolon of other Cyclosalpas. Our specimens do not show more than the beginnings of whorls. The position of the heart is indicated by a slight evagination in front of the intestinal caeca.

The form of the aperture of the dorsal tubercle is shown in figure 16. It is much simpler than in other solitary Cyclosalpas except the nearly related *C. bakeri*.

The horseshoe-shaped eye, the neural glands, and the outgrowths from the ganglion in connection with the neural glands agree so closely with the corresponding organs in the solitary *Cyclosalpa pinnata* and *C. affinis* as to need no description.

CYCLOSALPA FLORIDANA, aggregated form.

Plate 5, fig. 15; and plate 6.

Our figures and descriptions are based on the study of ten individuals from 6 to 9 mm. in length, collected in May and June, 1907, near Nassau, Bahama Islands. These are the specimens used by Brooks (1908) in the preparation of his paper upon this species. Some of Brooks' specimens have been deposited in this museum (U.S.N.M., Cat. No. 6676). We have also a poorly preserved specimen from the Gulf of Mexico, off Mobile Bay, United States National Museum, Cat. No. 6453 (aggregated form), *Albatross* station D 2402; off Cape San Blas, Gulf of Mexico; March 14, 1885; 111 fathoms; surface temperature 63° F.; one specimen.

The general form of the body is very different from that of the aggregated *Cyclosalpa pinnata* and *C. affinis*, being roughly triangular in side view, and the very noticeable postabdomen emphasizes the distinct appearance. In details of structure, however, the resemblance to the other Cyclosalpas is seen. The test is enlarged even more than in *C. affinis*. Luminous organs are entirely lacking.

Study of the body muscles shows but three. The intermediate muscle and the first body muscle are essentially similar to those of the aggregated *C. affinis*. The second body muscle of *C. affinis* and *C. pinnata* seems to be the one missing in *C. floridana*. It may be altogether lacking, but study of the aggregated *C. bakeri* suggests that its fibers may be fused with one of the other body muscles. The second and third body muscles of *C. floridana*, corresponding probably to the third and fourth of *C. affinis* and *C. pinnata*, are united in the manner shown in the figure. Noting a few details: observe that the intermediate body muscle passes outside the oral retractor, that ventrally it unites with its fellow of the opposite side, and that the common strand thus formed is continued back into the very slender peduncle where it forms the anterior half of the single muscle. The third body muscle and its branches show a combination of characters which appear separately in *C. pinnata* and *C. affinis*, though nothing not found in one or the other of these species. From its upper part arises the atrial sphincter. (See last body muscle in *C. pinnata*.) The posterior branches of these muscles on the two sides of the body unite on the mid line below the base of the atrial siphon, and are continued on the mid line downward into the base of the postabdomen, stopping in the bend of the intestine, thus resembling *C. affinis*. From the lower end of the third muscle, on each side, arises a small strand, which curves backward and upward also into the postabdomen, as in *C. affinis*. This muscle on the left side is continued into the tubular portion of the postabdomen. On the right side its fellow ends near the enlargement referred to as a rudimentary stomach. Note that this third body muscle with its connections resembles not the third but the fourth body muscle of *C. pinnata* and *C. affinis*.

As in the solitary form, the atrial sphincters are few in number. The oral muscles are simpler than in the solitary form of this species or either form of *C. pinnata* or *C. affinis*. There is a single oral retractor running forward from the first body muscle. This divides anteriorly into three dorsal and three ventral branches forming the three sphincters of the dorsal and the ventral lips respectively.

The upper lip in both forms of this species is the larger externally, but the lower lip is enlarged internally and shows the same type of valve structure described for *Cyclosalpa pinnata*.

The gut is a little more curved than in *C. affinis*, the intestine crossing the esophagus so that the anus is behind and above the esophageal aperture. There is no caecum, but, as in the aggregated *Cyclosalpa affinis*, there is an enlargement of the intestine just behind its union with the esophagus. This stomachlike enlargement is greater than in *C. affinis*. The intestinal gland is present in the usual form, but to avoid the confusion of too many lines it is not shown in our figures.

The testis, instead of lying along the intestine as in *Cyclosalpa pinnata* and *C. affinis*, pushes out far behind the body, completely filling a long conoidal evagination of the mantle. Its duct passes above the intestine, through its loop, to open dorsal to the anus. The ovary lies just behind the last body muscle, instead of in front of it, as in *C. pinnata* and *C. affinis*. Its duct, however, passes forward, as in these latter species, to a point behind the next to the last body muscle. The heart has the usual position. The simple outline of the aperture of the dorsal tubercle is shown in figure 16, plate 5. The ganglion and glands are as in *Cyclosalpa pinnata* and *C. affinis*. There are paired outgrowths from the ganglion toward the disks of the neural gland, as in other Cyclosalpas.

The large dorsal eye (fig. 16, this page) is much as in *Cyclosalpa affinis*, except that it is a little more compact. The transverse plug of optic cells (*e.'''*) behind and above the apical portion of the eye, is less distinct, being crowded against and into closer union with the rest of the eye, one common pigment layer serving the rod-cells of both the optic plug and the apical division of the eye.

Cyclosalpa floridana has been studied by Apstein (1894, *b*, not 1906, *b*), Brooks (1908), and Ihle (1910). Our studies result in considerable disagreement with the first two of these authors. Apstein's figures lack details of the organs other than the muscles. The whole oral muscular system of the solitary forms he describes very differently, showing no dorsal oral retractor, two instead of three ventral lip sphincters, and different connections for all the oral sphincters. He does not show the atrial retractor. There is so little detail in his figures of the aggregated form that comparison with our results is difficult. No muscles are shown upon the ventral lip. He figures no connection between the third sphincter of the upper lip and the intermediate muscle. He shows but one muscle, the intermediate, continued into the peduncle. He unites the ventral ends of the first and second body muscles. He shows no branches from the third body muscle into the post-abdomen. He figures but one atrial sphincter.

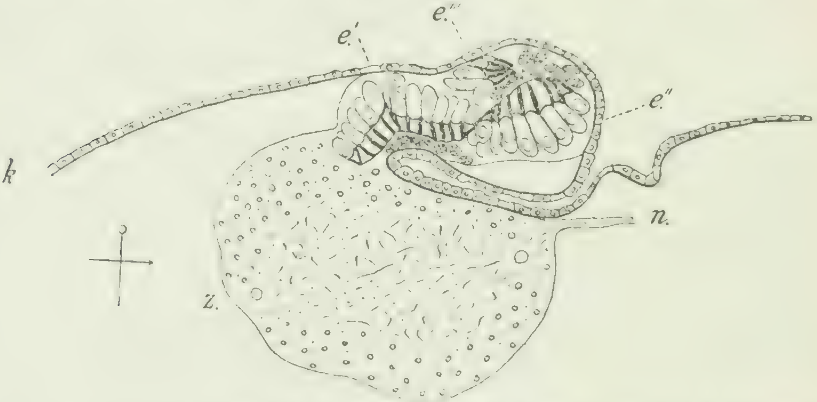

FIG. 16.—CYCLOSALPA FLORIDANA, AGGREGATED FORM, A SAGITTAL SECTION OF THE GANGLION AND DORSAL EYE. × 300 DIAMETERS.

Brooks, who studied the same specimens we used, gives a much fuller description than Apstein. In the solitary form we find one dorsal sphincter and two ventral sphincters in addition to those which he shows in the oral region of his adult specimens, but in his figure of a large embryo 4.5 mm. long he shows six instead of our four dorsal sphincters and one instead of our three ventral sphincters. Brooks figures the dorsal and ventral oral retractors in this embryo, but gives them different relations with the oral sphincters. We have not had this embryo for study with Brooks' other specimens. Brooks does not figure the atrial retractor. We find the intermediate muscle and the first two body muscles approximated dorsally, but not actually united as Brooks figures and describes them in the adult. Part of the discrepancies between Brooks' results and ours may be due to the fact that he describes the appearance of the animal, in side view, and only for the embryo, while our studies are of adult individuals.

As to the structure of the aggregated form also, we find some discrepancies between Brooks' results and ours. He shows two fewer ventral oral sphincters than we. He prolongs the intermediate muscle and body muscle II, instead of the intermediate muscle and body muscle I, into the peduncle, carrying the ventral end of body muscle I back to join that of body muscle III. Observation of our figure 15 on plate 5 will explain the condition in this region, which might easily mislead if not studied under high magnification. Brooks shows no prolongation of any branches of body muscle III (as we number it) into the visceral protuberance.

Ihle's description of the solitary form is based upon Brooks' studies. He gives a good description of the aggregated form, and he shows very clearly Apstein's mistake in confusing *Cyclosalpa floridana* (Apstein, 1894), and *C. bakeri* which Apstein (1906) calls *C. floridana*. Ihle worked upon much younger zoöids of the aggregated form than we, and our slight differences from his results may be due to this fact. We show one more dorsal and two more ventral sphincters than he. Also he does not figure the posterior branch of the third body muscle (our number) as continued, after union with its fellow, into the visceral protuberance. It is interesting to note that he figures the large dorsal eye in his young zoöid as pointing postero-dorsally, while in our older individuals it is directed antero-dorsally. This indicates a forward rotation of this eye in its later development, similar to that which occurs in the aggregated *Cyclosalpa pinnata*.

CYCLOSALPA BAKERI Ritter, 1905.

C. floridana APSTEIN, 1906, *a*, not 1894, *b*.
C. bakeri IHLE, 1910.

This species, confused by Apstein (1906, *a*) with *C. floridana*, shows more than superficial resemblance to the latter species in both solitary and chain forms, but is a clearly distinct species, differing in many points of structure and form. Our figures and the description are based on studies of three specimens of the solitary form, most generously given by Professor Ritter, the discoverer of the species, and upon three specimens of the aggregated form collected in Philippine waters by the United States Bureau of Fisheries steamer *Albatross* (station D, 5437, between Bohol and Leyte, north of Minbanao). The specimens given by Professor Ritter came from off the California coast. Two of the three have stolons with well-formed zoöids. Specimens of both the solitary and aggregated individuals are in the United States National Museum.

Cat. No. 6476, U.S.N.M. (solitary form), off San Pedro, California, (W. E. Ritter); 3 + specimens.

Cat. No. 6456, U.S.N.M. (aggregated form), *Albatross* station D 5437, Hermana Mayor Light, west coast of Luzon; May 8, 1909; 100–600 fathoms; surface temperature 86° F.; 3 + specimens.

CYCLOSALPA BAKERI, solitary form.

Plate 7.

This is very similar to the solitary *Cyclosalpa floridana*, but there are marked differences. The shape of the body, the test, and the luminous organs in the two are similar, though our specimens of *C. bakeri* show the latter more developed than they are in our specimens of *C. floridana*. All the body muscles are distinct in the solitary *C. bakeri* and none of them are continued across the mid-ventral line. The sixth body muscle on each side, in its dorsal portion, turns forward, passing the dorsal ends of the fifth and sixth body muscles. The dorsal oral retractor gives rise, strictly speaking, only to the first or admarginal sphincter of the lower lip. The second sphincter of the upper lip has its fibers inserted upon, but not a part of, the retractor. The first sphincter of the upper lip is continuous directly with the second sphincter of the lower lip, the two forming one continuous muscle. The third sphincter of the lower lip is a branch of the ventral retractor, as in the solitary *Cyclosalpa pinnata*. The basal three atrial sphincters are well developed and form something of a network, in which one can recognize ventrally the diagonal atrial retractor in its typical position. The delicate atrial sphincters are twice as numerous as in the solitary *Cyclosalpa floridana*.

For the gut, we need mention only the two caeca, which are of approximately equal size, and are larger than in the solitary form of any other species of *Cyclosalpa*.

Figure 20 shows the contour of the aperture of the dorsal tubercle, slightly more curved than in the solitary *Cyclosalpa floridana*. The stolon is straight, lying wholly on the mid-ventral line, instead of bending to the right as in our specimens of the solitary *C. floridana*.

Opposite the lower part of the intermediate muscle are a pair of languet-like processes of the mantle, one on each side. They resemble the corresponding structures in the solitary *Cyclosalpa pinnata.*

The ganglion, the neural glands, the outgrowths from the ganglion toward the neural glands, and the horseshoe-shaped dorsal eye are as in the solitary forms of the other Cyclosalpas already described.

CYCLOSALPA BAKERI, aggregated form.

Plates 8, 9, and 10.

In the aggregated form of this species we find again considerable resemblance to the aggregated *Cyclosalpa floridana,* in general shape and in the very flabby character of the animals, but they are sharply distinguished by many features, as Ritter and especially Ihle have shown. The younger zoöids, 4 mm. long, just detaching from the stolon, are different in shape from the larger Philippine specimens, 12 mm. long. The older individuals (pl. 8, fig. 21) have a longer atrial siphon and they seem to have lost the humpbacked form so noticeable in the younger zoöids, but our three older individuals are all so soft and flabby that it is difficult to be confident of the exact shape. It is, however, certain that the dorso-ventral diameter in front of the atrial siphon is relatively greater in the younger individuals. A marked difference between the older and younger zoöids in the arrangement of the oral muscles will be noted when we reach this part of the description.

The body muscles have a different arrangement on the right and left sides of the body, this species being one of the *Cyclosalpae asymmetricales.* The intermediate muscles and their prolongation into the peduncle are as in the aggregated *Cyclosalpa floridana.* The first and second body muscles on the left side are fused dorsally and ventrally, but are distinct and widely separated through the middle part of their course. Both share in the formation of the posterior peduncle muscle. On the right side of the body there is a diagonal strand which we interpret as the second body muscle fused at its lower end with the first body muscle, and in its upper portion fused with the third body muscle. Comparison with the aggregated *Cyclosalpa floridana* suggests that, in the latter species, the muscle we have numbered I may in reality be equivalent to muscles I and II of *C. bakeri.* Its approach ventrally, in *C. floridana,* to touch muscle II and then passing on into the peduncle may be somewhat similar to the fact that muscle II in *Cyclosalpa bakeri,* if we correctly homologize it, connects with both muscle I and muscle III. On the left side of *C. bakeri,* muscles III and IV are united exactly as are the muscles numbered II and III in *Cyclosalpa floridana.* All their branchings are the same. This is true of the right side also, except that the muscle we number II joins dorsally muscle III. The three muscles to the post-abdomen are closely similar to those in the aggregated *C. floridana*. The larger, median one, entering from above, terminates near the base of the post-abdomen, in the loop of the gut (pl. 10, fig. 25). Of the pair of more slender bands, arising from the lower part of the last body muscle, on each side, that on the left side is prolonged almost to the tip of the long slender testis, while that on the right side passes along the caecum and on nearly to the tip of the slender mass of degenerate (?) cells. This structure lying at the tip of the caecum is probably homologous with the cells at the tip of the caecum in the aggregated *Cyclosalpa virgula* and with the organ in the solitary forms of *Ritteria retracta*, *R. picteti*, and *R. amboinensis*, which Ihle regards as a blood-forming organ.

The peduncle muscles are, first, a fused anterior pair derived from the ventral ends of the intermediate muscles; second, a partially fused posterior pair derived from the ventral ends of the united first and second body muscles; and, third, a median strand arising at the ventral point of the united fourth pair of body muscles and running forward on the ventral mid line, past the third pair of body muscles from which it receives additional fibers, then passing forward, sometimes between the separated upper portions of the posterior pair of peduncle muscles, and bending down into the peduncle.

The muscles of the atrial siphon are as in the aggregated *Cyclosalpa floridana*, except that there are twice as many of the delicate sphincters. The oral muscles must receive separate description for the younger and the older zoöids. In the younger zoöids (fig. 22, pl. 8, and fig. 23, pl. 9) there is a well-developed oral retractor connected as usual with the first body muscle. Passing forward, this gives rise ventrally, first, to the third sphincter of the lower lip, then to a second ventral branch, the second sphincter of the lower lip, and finally passes into the first sphincter of the lower lip. The first sphincter of the upper lip arises on each side as a branch of the second sphincter of the lower lip. The second and third sphincters of the upper lip unite ventrally to form a common trunk which posteriorly joins with the ventral half of the intermediate muscle, not with the first body muscle. This arrangement of this muscle is comparable with what we find in the aggregated *Cyclosalpa pinnata* and *C. affinis*, except that the union of the diagonal strand with the intermediate muscle is further toward the ventral side. It seems hardly natural to call this a ventral oral retractor, for its attachments are different, but it functions in much the same way. The dorsal longitudinal muscle band does not extend quite far enough forward to come into contact with the fourth sphincter of the upper lip, differing in this regard from the aggregated *Cyclosalpa floridana*. The relations in the older zoöids are the same, except that the first sphincters of the dorsal and the ventral lips are continuous, forming one muscle, which has no connection with the oral retractor.

This divergence in the connection of the admarginal oral sphincters in the younger and older zoöids makes one at first doubt the constancy of detail in the arrangement of the muscles in at least the aggregated Salps, but we have as yet no sufficient studies of variation in the Salpidae to determine this matter conclusively. In the aggregated zoöids, as in the embryo, there are considerable changes during the process of establishing the adult condition of the muscles, but, once fully developed, these conditions so far as our studies indicate are constant.

The gut forms a long narrow loop, lying chiefly outside the body proper, in a long protuberance conveniently named by Ritter the post-abdomen. At the point of union of esophagus and intestine arises a long slender caecum, which passes out into a separate slender pouch of the post-abdomen. These relations are best shown in the dextrodorsal view drawn in figure 25, on plate 10. Observe the intestinal gland, opening into the intestine at the point of origin of the caecum and running across the space in the loop of the gut, to branch over the distal portion of the intestine.

The elongated testis (pl. 10, fig. 25, *t.*) fills nearly the whole of the larger of the two slender mantle pouches connected with the post-abdomen. Its duct passes over the bend of the intestine and dorsal to its distal end. In the younger zoöids we can not trace it beyond this point, but in one of the three larger zoöids, which we stained, we could trace a faint line of apparently degenerating duct forward on the right side until it joined the oviduct a little beyond the young embryo. The ovary lies on the right side, in front of the last body muscle, the oviduct extending forward nearly to the third body muscle.

At the tip of the caecum is an elongated, spindle-shaped group of cells of problematic nature (*q* in fig. 25, pl. 10). They resemble elaeoblast cells. The heart is in the usual position. Below it, in the younger zoöids, is a vesicle subtended by a layer of cells whose appearance again suggests comparison with elaeoblast cells. There is little value in discussing the nature of either group of these elaeoblast-like cells until their development is known.

The outline of the aperture of the dorsal tubercle is shown in figure 24, plate 9.

The ganglion, the neural glands, and the outgrowths from the ganglion, near the glands, resemble these organs in the aggregated *Cyclosalpa floridana.* The large dorsal eye (fig. 17, this page) also is very similar, the only notable difference being that the optic plug is still more intimately fused with the postero-dorsal face of the apical region of the eye. The presence or absence of accessory eyes in the ganglion can not be determined from sections of our poorly preserved formalin material of the young zoöids, and it does not seem best to sacrifice one of our two remaining older zoöids, the largest yet seen of this species.

Cyclosalpa bakeri, discovered by Ritter, has been carefully described by him. We modify his results but slightly and add little

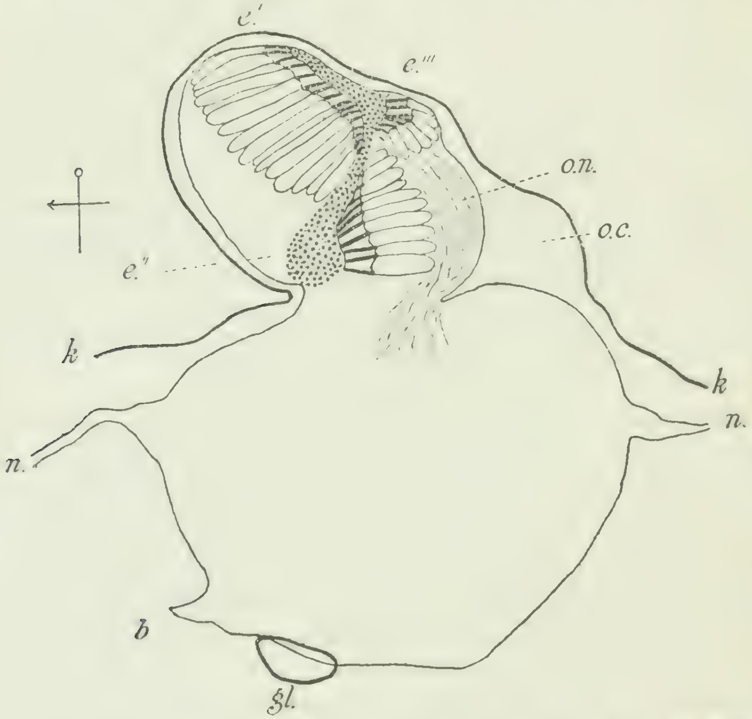

FIG. 17.—CYCLOSALPA BAKERI, AGGREGATED FORM, AN OPTICAL SECTION OF THE DORSAL EYE, WITH OUTLINE OF THE GANGLION AND ONE NEURAL GLAND. × 175 DIAMETERS.

to them except as to the anatomy of the eye of the aggregated form. In the solitary form we find a more complicated arrangement of the atrial sphincters which we find also more numerous than Ritter shows them. In our specimens, the oral retractor runs outside the intermediate muscle and the ventral oral retractor. Ritter shows it internal to them. He omits one sphincter of the lower lip (our first) and shows the connections of the other oral sphincters slightly differently from ourselves. (Ritter directs attention to considerable variation in the aggregated form.) There is an error in his drawings of the solitary form, doubtless inadvertent, though twice repeated.

for he shows the peripharyngeal bands connecting dorsally with the horns of the dorsal tubercle instead of with the anterior end of the gill. The latter is of course the arrangement not only in all the Salpidae, but in all Tunicata.

The results of our studies of the aggregated form agree with Ritter's, except for a few minor details. We show differently the visceral muscle prolonged into the base of the post-abdomen from the median line of the united posterior branches of body muscle IV. We show three more atrial sphincters than he. We show one more sphincter muscle in the lower lip and three instead of four sphincters in the upper lip, and slightly different connections for the sphincters of both lips. The zoöids Ritter describes are slightly younger than the youngest we studied and much smaller than our three larger specimens.

Ihle's careful review of this species showed the accuracy of Ritter's studies and the confusion in the work of Apstein, who refused recognition to *Cyclosalpa bakeri* as a species distinct from *C. floridana.*

CYCLOSALPA VIRGULA (Vogt 1854).

Salpa virgula Vogt, 1854.
Salpa dolichosoma Todaro 1883.
Cyclosalpa dolichosoma-virgula Herdman, 1888.

In the aggregated form of this species there is greater bilateral asymmetry than in any other species. Our studies of the species are based upon finely preserved material obtained from the Zoölogical Station in Naples. There are 11 individuals of the aggregated form and one large solitary individual. The solitary individual, and one of the aggregated zoöids are deposited in the United States National Museum: Cat. No. 6465, (aggregated form), from Naples Zoological Station; one specimen. Cat. No. 6475, (solitary form) from Naples Zoological Station; one specimen.

CYCLOSALPA VIRGULA, solitary form.

Plate 11, figs. 26 and 27.

The muscles of this form have been well described by Streiff (1908), and detailed description is hardly needed here. Observation of our figure will show the points of comparative interest. The intermediate muscle is continuous across the mid-ventral line, as in the solitary forms of all Cyclosalpas. All the body muscles are interrupted dorsally and ventrally. The forward prolongation of the dorsal ends of the sixth body muscles, seen in the solitary *C. bakeri*, is, in *C. virgula,* carried much further, the dorsal ends of the sixth and first muscles being thus united. Similarly the ventral ends of the fifth body muscles are turned forward and the ventral ends of the first body muscles turned backward, until, in our specimen, they almost meet opposite body muscle III. In Streiff's specimens these ventral prolongations met and united into a continuous band. The arrangement of the oral retractors in our specimens recalls the aggregated *Cyclosalpa affinis.* Streiff found a different condition, the ventral oral retractor in his specimens being split posteriorly into an upper and a lower branch, both extending back to and inserted upon the first body muscle. The upper branch was in contact with the lower edge of the dorsal retractor. The lack of continuity of the third and fourth sphincters of the upper lip with any of the other muscles is again comparable to the condition in *C. affinis.* The atrial muscles show a very well-developed retractor continuous dorsally with four of the atrial sphincters and ventrally in contact with but not continued into five of the atrial sphincters. The two papillae, one on each side of the atral opening, recall the solitary *Cyclosalpa affinis.*

The gut is very similar to that of the solitary *Cyclosalpa pinnata*, there being two caeca. The tip of the intestine is curled further back than in other species. At its anterior end the stolon, in our specimens, curls up on the left side and terminates in a thin thread.

The neuro-glandular complex shows no noteworthy difference from the corresponding organs of the solitary forms of the other Cyclosalpas.

CYCLOSALPA VIRGULA, aggregated form.

Plate 11, fig. 28; plates 12 and 13.

This is the most asymmetrical member of the Salpa family,[1] yet point by point it shows fundamental resemblance to the other species of *Cyclosalpa.* All of our nine individuals show the same asymmetry, there being no distinction between dextral and laeval individuals. In general shape the zoöid somewhat resembles *C. bakeri*, but has an undivided post-abdomen more like *C. floridana.* The test is like that of *C. bakeri.* There is no stalk of attachment (peduncle), the zoöids being sessile upon the stolon, which is shown as a large tube on the ventral side of the animals we figure.

Four body muscles can be recognized, as in all other aggregated Cyclosalpas except *C. floridana* (in which the second is either wanting or is fused with muscle I), but in *C. virgula* the arrangement of these muscles is much modified, chiefly by partial fusion with one another, these fusions being very different on the two sides. The intermediate muscle and all the body muscles are interrupted ventrally (pl. 12, fig. 30). On the right side (pl. 11, fig. 28) the upper end of the intermediate muscle bends back in the usual *Cyclosalpa* manner and unites with the first body muscle, but this union is far down on the side, just above the oral retractor. In fact, the back-turned end of the intermediate muscle fuses with the posterior end of the oral retractor. On the left side (pl. 12, fig. 29) the upper end of the intermediate muscle does not quite reach to the first body muscle, but runs far up dorsally and stops before establishing the connection. It is as if the whole muscle system were so twisted over to the right side that the intermediate muscle on the left side, blocked by the ganglion, fails to reach its proper point of union with the first body muscle, while, on the right side, this attachment is present and by the same lateral twist is pushed ventralward.

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[1] The aggregated zoöids of *Brooksia rostrata* are nearly as asymmetrical, so also are those of *Apsteinia asymmetrica.*

On the right side the first body muscle, in its upper half, unites with both the intermediate muscle and the second body muscle, separating again further dorsally to pass over the actually (morphologically?) mid-dorsal line as a broad band whose breadth suggests that it contains some fibers properly referable to the intermediate muscle. On the left side, muscle I is distinct from both the intermediate muscle and body muscle II and does not even come into contact with the oral retractor.

On the right side, body muscle II joins the intermediate muscle and body muscle I above, as already noted, but a little further dorsally it parts company with them and, after a very short free course, unites with the fused muscles III and IV. This union is less perfect than in the case of some other muscles, for the line of demarcation between muscle II and the fused muscles III and IV can be traced through the whole course of their juxtaposition, across the mid-dorsal line, onto the left side. On the left side, muscle II joins the united muscles III and IV, but not the intermediate muscle or body muscle I. Here, again, the impression is that of a shifting of the muscles, over the dorsal surface, toward the right side.

On the right side, muscle III, in its upper half, is attached to muscle IV, but its fibers are not continued dorsally in union with the latter muscle. On the left side the union of III and IV is more intimate, their fibers passing together across the dorsal surface.

Muscle IV has its usual position, its ventral ends lying in front of the gut, while the posterior branch passes behind the gut, above the post-abdomen, to unite with its fellow from the opposite side. On the right side, the two parts of this muscle are separated so that the anterior branch does not quite touch the band which passes back above the post-abdomen. On the left, the two branches are united. In the aggregated forms of other species of *Cyclosalpa* the posterior branches of muscle IV (or its homolog in *C. floridana*), at their point of union on the mid line, give rise to a band of muscle which runs on the mid line into the more or less developed post-abdomen. In the aggregated *C. virgula* the corresponding muscle arises well on the right side, but has a similar course into the base of the post-abdomen. Its position, on the right side rather than in the median plane, is another indication of the shifting of the whole muscular system toward the right. The dorsal view (fig. 33, pl. 13) gives the best impression of this great lateral distortion. Careful study of the origin and position of the zoöids upon the stolon might give the key to this distortion, but we have not material to undertake this.

The atrial muscles show a well-developed retractor on each side, whose position and connection with the atrial sphincters, when carefully compared, is seen to have some resemblance to what is found in the solitary form. The atrial retractor is not connected with the basal two sphincters on either side. These basal atrial sphincters are continuous on the right side, from the dorsal to the ventral surface. On the left side they are interrupted, and in front of the point of interruption the ends of the two are united into a common strand, which runs toward but not into contact with body muscle IV, suggesting comparison with the atrial retractors in the aggregated forms of other species of *Cyclosalpa*. Comparison with the solitary *C. virgula* indicates that that which corresponds to the continuous atrial retractor in the solitary form is, in the aggregated form, divided into two portions, proximal and distal, of which the distal portion, connected with the delicate sphincters, is present on both sides of the body, while the proximal portion, connected with the heavier basal two sphincters, is seen only on the left side, and even on this side is imperfectly developed.

The oral muscles are essentially alike on the two sides, but are less compact, and so more readily observed, on the right side. There is a single strong oral retractor which, on the right side, passes backward outside of and then joins the dorsal part of the intermediate muscle and runs with it to its insertion upon body muscle I. On the left the oral retractor passes over the intermediate muscle, but is not united to either this or body muscle I. Four sphincters of the lower lip and one sphincter of the upper lip are connected directly with the oral retractor on each side, as shown in the figures. The second sphincter of the upper lip is independent of all other muscles. This is seen more readily on the right side, where the oral muscles are not so crowded. The third (last) sphincter of the upper lip is a branch of the intermediate muscle on each side of the body. The band of muscle, which, in the aggregated *Cyclosalpae symmetricales,* connects the dorsal portions of the last sphincter of the upper lip with the intermediate muscle, does not, in the aggregated *C. virgula,* make actual connection with the last oral sphincter on either side. This is also true of the other asymmetrical species, *C. bakeri.*

The gut resembles that of the aggregated *Cyclosalpa bakeri,* though its caecum is directed forward on the right side of the body (fig. 30, pl. 12) instead of protruding into a separate evagination of the mantle as in *C. bakeri.* This caecum arises from the left side of the intestine (fig. 28, pl. 11), but bends over to the right side of the enlarged base of the post-abdomen. It is really the morphological left caecum. There are a few loosely arranged degenerate (?) cells at the tip of the caecum, corresponding to the fusiform mass of such cells one finds in *C. bakeri.* There is a slightly developed right caecum. The position of the intestine in our figure 30, plate 12, a ventral view, is a little distorted by slight rotation, the large caecum being pulled a little to the right, so as to allow one to see the smaller, morphologically right caecum, which in ventral view is hidden by the base of the large caecum. The dorsal view (fig. 33, pl. 13) shows the true positions. The intestinal gland is seen from figures 28 and 29, plates 11 and 12, and figure 33, plate 13, to have the usual arrangement.

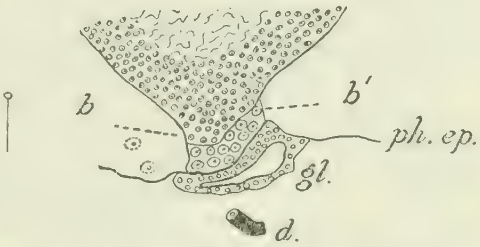

FIG. 18.—CYCLOSALPA VIRGULA, AGGREGATED FORM, AN OBLIQUE LONGITUDINAL SECTION THROUGH THE NEURAL GLAND AND THE OUTGROWTHS FROM THE GANGLION. FROM METCALF AND JOHNSON (1905).

The testis lies in the distal portion of the great post-abdomen. Its duct has the usual course and opens into the atrial chamber, not far from the anus. The ovary is on the right side, in the usual position, between body muscles III and IV.

The outline of the aperture of the dorsal tubercle is shown in figure 32, plate 13.

The ganglion (fig. 31, pl. 13) shows no features of moment for our studies except the eyes and the outgrowths toward the neural glands. These glands are of the usual disk form with convoluted ducts leading from them (fig. 18, this page). There is a protuberance from the ganglion toward each glandular disk, the base of each protuberance containing small cells like the small cells of the ganglion, the distal portion of each protuberance containing a mass of larger cells, this group of cells being separated from the smaller cells by a distinct membrane.

The larger dorsal eye is seen in figure 31, plate 13, and figure 19, on this page (copied from Metcalf and Johnson, 1905). The section shows that the eye is divided into two main portions; a basal portion (*e′*) in which the rod-cells are dorsal to the pigment, and a terminal portion (*e″*) in which the rod cells are ventral to the pigment. A little behind the mid-dorsal point of this eye there is an area of thickened pigment partially surrounding a group of larger cells which are the remnant of the optic plug (*e‴*, see also fig. 20) which in *Cyclosalpa pinnata* and *C. affinis* is much better developed. In *C. floridana* and *C. bakeri* the optic plug becomes more closely united to the apical portion of the eye. In *C. virgula* there is but a vestige of this structure. The vestigial condition of its optic plug shows that, in the character of its large dorsal eye, *C. virgula* is intermediate between the more archaic Cyclosalpas on the one hand and the Apsteinias, Salpas, and other subgenera on the other. The optic nerve enters the eye passing above the basal rod cells (fig. 19).

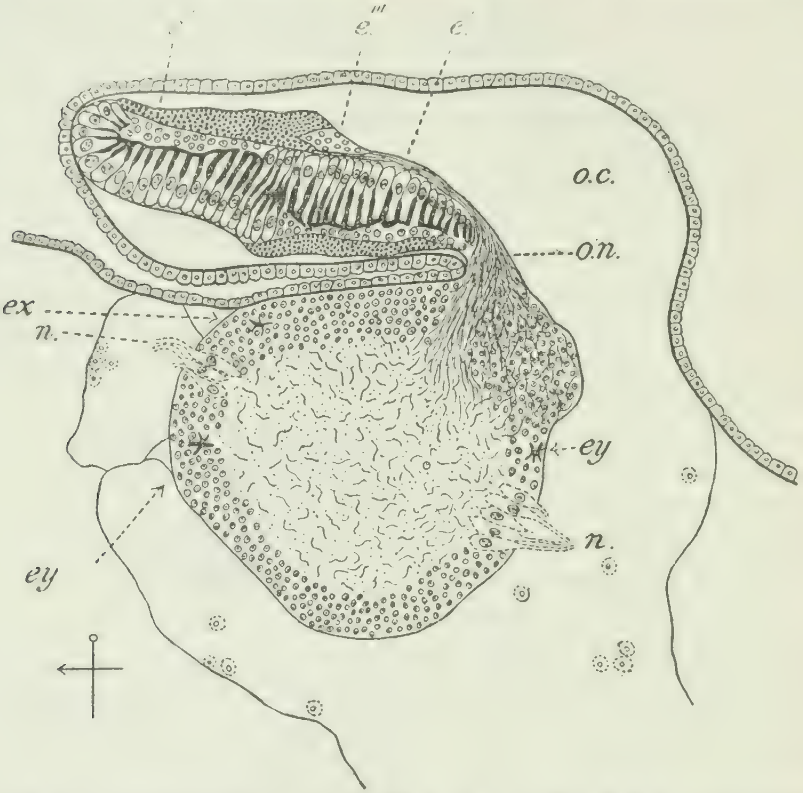

FIG. 19.—CYCLOSALPA VIRGULA, AGGREGATED FORM, A SAGITTAL SECTION OF THE GANGLION AND DORSAL EYE. FROM METCALF AND JOHNSON (1905).

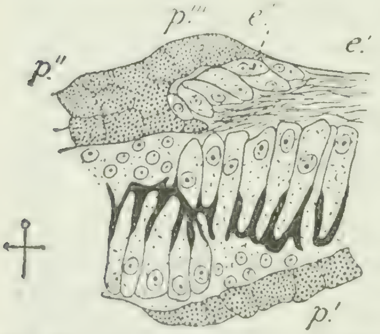

FIG. 20.—CYCLOSALPA VIRGULA, AGGREGATED FORM, THE MIDDLE PORTION OF THE SECTION OF THE DORSAL EYE SHOWN IN FIG. 19, MORE HIGHLY MAGNIFIED. FROM METCALF AND JOHNSON (1905).

In the ganglion, accessory smaller eyes are present (fig. 19, p. 48). These groups of imperfect rod-cells have no pigment associated with them. The groups vary in number and position, but have about the same structure, which is shown in figure 21. They are to be compared with the better developed accessory eyes of the other Cyclosalpas.

Just behind the optic nerve, at its origin, the ganglion is swollen to form a considerable protuberance whose cells, however, are not developed into rod-cells as they are in the corresponding part of the ganglia of some other species, as *Apsteinia punctata*, *Apsteinia asymmetrica*, *Salpa fusiformis*, *S. cylindrica*, and, as I interpret the relations, in the Thalias.

The musculature of *Cyclosalpa virgula* has been very carefully studied by Streiff (1908). For the solitary form he shows slightly different arrangement of the oral retractor muscles, the dorsal retractor being double and the ventral retractor uniting with the ventral division of the dorsal retractor. The ventral horizontal bands, connecting body muscles I and V, he shows as continuous. We find them interrupted. The dorsal longitudinal muscle band back of the upper lip he shows in contact with the last sphincter muscle of the dorsal lip. In our specimens these muscles are not in contact. Doubtless all these differences in our descriptions are due to differences in the specimens studied and indicate individual divergence within the species.

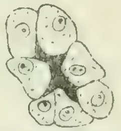
FIG. 21.—CYCLOSALPA VIRGULA, AGGREGATED FORM, A SECTION THROUGH ONE OF THE ACCESSORY EYES IN THE GANGLION. FROM METCALF AND JOHNSON (1905).

In the aggregated form, Streiff does not show the posterior branches of the last body muscle (our muscle IV, *b*) to be united above the post-abdomen (doubtless again divergence between his specimens and ours), nor does he describe any visceral muscle arising from the last body muscles and running into the base of the post-abdomen. We suspect that here Streiff failed to see a structure which was present, as he also fails to note the corresponding muscle in the aggregated *Cyclosalpa pinnata*.

THE CYCLOSALPAS IN GENERAL.

In our introductory remarks, and in the course of the descriptions of the several species, we have made numerous comparisons between the species of *Cyclosalpa*. The division of the subgenus into *Cyclosalpae symmetricales* and *Cyclosalpae asymmetricales*, while truly descriptive of the existing conditions, does not represent accurately degrees of relationship, for *Cyclosalpa bakeri*, an asymmetrical form, finds its nearest relative in *C. floridana*, an aberrant member of the group *symmetricales*. (Compare the chart on p. 158.) We have already noted that in the family Salpidae only the aggregated zoöids are asymmetrical, and that among Cyclosalpas only species which are not known to form whorls on the stolon show this asymmetry.

We can say that there is one type of muscular arrangement underlying the somewhat divergent conditions in the solitary forms of the whole subgenus *Cyclosalpa*, and another equally well-marked type underlying the various conditions seen in the aggregated zoöids of all species of the subgenus. The evidence from the muscles points to the acceptance of the subgenus as a natural one. This conception of natural relationship is strongly borne out by the conditions in the eyes, in the outgrowths from the ganglion, and in the neural glands.

The gut is similar in position and structure in the solitary forms of all the species, except that in *Cyclosalpa floridana* the caeca are small and in *C. affinis* one is missing. The solitary Cyclosalpas are the only Salpidae which have the gut lying along the dorsal side of the gill. In the aggregated zoöids, on the other hand, we find the more aberrant species of the subgenus approaching the true *Salpae*, the gut becoming bent into a loop, which however is not, in any species, compacted into what could be called a "nucleus."

Similarly, in the aggregated forms, the large eye of the asymmetrical species approaches the condition seen in *Ritteria*, *Apsteinia*, and the true *Salpae*.

BROOKSIA, new subgenus.

BROOKSIA ROSTRATA (Traustedt 1893).

Salpa rostrata TRAUSTEDT, 1893.

This subgenus I name after Prof. W. K. Brooks, who has so exhaustively studied the Cyclosalpas and whose studies of other members of the *Salpidae* have been extensive. Its only species, *rostrata*, resembles *Cyclosalpa virgula*, but differs from this species in having the gut, in both solitary and aggregated forms, in the shape of a rather close loop, much as is the case in the Ritterias. I have no specimens of this subgenus.

BROOKSIA ROSTRATA, solitary form.

This has been studied by Traustedt (1893), Apstein (1894, *b*), and Ihle (1910). The shape of the body is very peculiar for a solitary *Salpa* (figs. 22, and 23, p. 51). It has a great antero-ventral protuberance from below the mouth, equal in length to the whole of the rest of the body. In the aggregated zoöids of *Salpa maxima*, *S. fusiformis* and *S. cylindrica* we find similar processes. They contain no musculature, but at least in some specimens, especially of *S. cylindria*, one finds connective tissue fibers running lengthwise in the anterior protuberance. At the base of the protuberance they are continuous on each side with the ventral end of the intermediate muscle. These fibers in the anterior protuberance in the *Salpae* might function in connection with the intermediate muscle to move the protuberance, much as the proboscis muscles in *Brooksia* must move the proboscis, were it not that the test in the *Salpae* (*sensu strictu*) seems too firm to allow much movement.

It is difficult, from the published descriptions and figures, to determine the number of body muscles, partly because the details of the oral region are not given for the adult form, so as to enable us to distinguish body muscles from oral muscles, and partly because there is disagreement between Apstein's figures of the embryo and Traustedt's and Ihle's figures of the adult. Traustedt and Ihle both show what seems to be an intermediate muscle and seven body muscles. All the body muscles are continuous across the mid line dorsally and there is here, in some specimens, no union anteroposteriorly between adjacent muscles. In other individuals, body muscles I, II, and III are united dorsally, as are also muscles IV, V, VI, and VII. The muscles of the proboscis are unique among the Salpidae. Traustedt's and Apstein's descriptions of them do not quite agree. In Apstein's figure of a side view of an embryo the dorsal bundle of muscles in the protuberance is continuous with the second sphincter of the lower lip. The ventral bundle of proboscis muscle fibers is prolonged on each side to nearly the posterior end of the body. It is doubtful if these bands are comparable to the less extensive ventral bands in the solitary *Cyclosalpa virgula* (pl. 11, fig. 26).

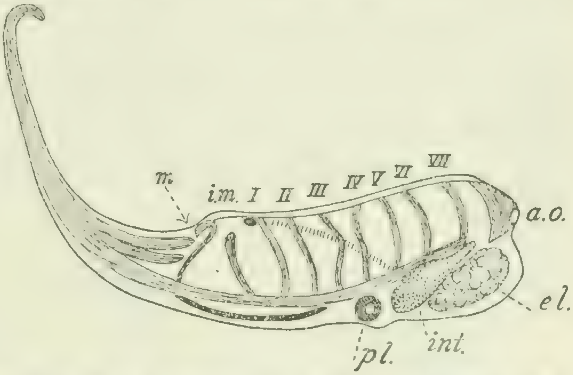

FIG. 22.—BROOKSIA ROSTRATA, SOLITARY FORM, VIEWED FROM THE LEFT SIDE. FROM TRAUSTEDT (1893).

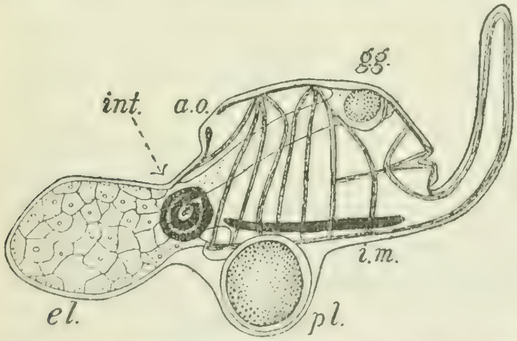

FIG. 23.—BROOKSIA ROSTRATA, EMBRYO, VIEWED FROM THE RIGHT SIDE. × 50 DIAMETERS. FROM APSTEIN (1894, *b*).

The oral muscles have been insufficiently described for use in detailed comparison. Apstein figures the presence of an oral retractor of the usual type and certain sphincters of the two lips. The atrial muscles are not described beyond Traustedt's figuring the presence of apparently very numerous delicate sphincters.

The gut is figured by Traustedt (1893) as apparently a compact "nucleus," but Apstein (1894, *b*) shows it in the embryo as a loop (fig. 23), but more compact than in any *Cyclosalpa*.

BROOKSIA ROSTRATA, aggregated form.

The aggregated form of *Brooksia rostrata* has been described only by Apstein (1894, *b*). It shows (fig. 24) about as much asymmetry as the aggregated *Cyclosalpa virgula*. The pattern of the asymmetry is constant, except that in some individuals it is exactly reversed. According to Apstein's description, in a dextral zoöid, there are four body muscles on the right side and three on the left, as is true of the aggregated *Cyclosalpa virgula*. On the right side the intermediate muscle and body muscles I and II are united, or at least in contact, dorsally, as in *Cyclosalpa virgula*. Muscle III joins muscle II much as it would in *C. virgula* if the muscles were crowded toward the mid-dorsal point, as is the case in at least the young zoöids of *Brooksia rostrata*. Body muscle IV is similarly drawn forward, as contrasted with the condition in *Cyclosalpa virgula*. From muscle IV, on the right side, there is a branch (IV, *b*) running to near the base of the gut. On the left side of *Brooksia rostrata* there are three recognizable body muscles, as is the case on both sides of the aggregated *Cyclosalpa floridana*, in which species, as we have suggested, body muscles I and II may be fused. The body muscles of the aggregated *Brooksia rostrata* are thus seen to be of the *Cyclosalpa* type.

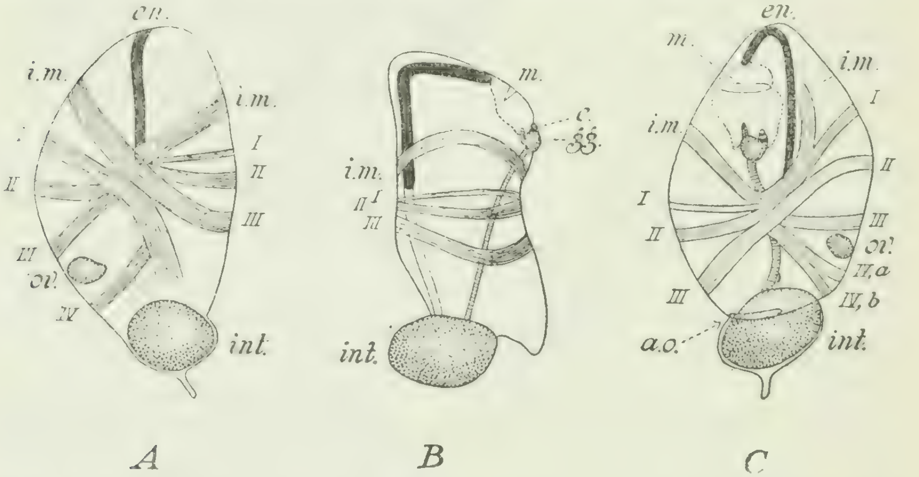

FIG. 24.—BROOKSIA ROSTRATA, AGGREGATED ZOOID: *A*, VENTRAL VIEW; *B*, VIEW FROM LEFT SIDE; *C*, DORSAL VIEW. × 40 DIAMETERS. FROM APSTEIN (1894, *b*).

Apstein figures the eye, but not in sufficient detail to avail for comparisons. If he shows accurately the disposition of the pigment, the eye of the aggregated form of this species is different from that of any other known species.

RITTERIA, new subgenus.

This subgenus includes the species *retracta, picteti, amboinensis,* and *hexagona.*

Ritteria amboinensis may be taken as the type of the genus, for it is nearer the norm of the genus than is *R. hexagona,* and these are the only two species in which the aggregated zoöid is well known.

This subgenus is characterized by having the gut ventral in the solitary form and less compacted into a nucleus than in the higher Salpidae, while in the aggregated zoöids of the only species whose aggregated forms are thoroughly known, *amboinensis* and *hexagona,* the gut is more closely coiled than in any aggregated *Cyclosalpa.* I have named the subgenus for Prof. W. E. Ritter, who described the species *retracta* and emphasized its resemblance to the Cyclosalpas. I have had for study specimens only of the species *amboinensis* and *hexagona* in this subgenus and base my conclusions as to classification largely on the studies of Apstein, Ritter, and Ihle.

RITTERIA RETRACTA (Ritter, 1906, b).

Cyclosalpa retracta RITTER, 1906, *b.*
Salpa amboinensis APSTEIN, 1906, *b,* not 1904, *b.*
Salpa retracta IHLE, 1910.

In none of the species of this subgenus is the gut in the solitary form found dorsal to the gill, but in *Ritteria retracta* and *R. picteti* it is elongated.[1] The esophageal aperture is a widely flaring, trumpet-shaped opening at the base of the gill (fig. 25, p. 54). The esophagus bends forward, then backward, much as in the aggregated *Cyclosalpa virgula.* The intestine runs backward on the left of the esophagus, its tip being bent a little upward and to the right to open by the anus into the atrium, just inside of the atrial aperture. The caecum extends forward from the point of juncture of esophagus and intestine. The resemblance of the gut to that of the aggregated *Cyclosalpa virgula* is striking. The chief differences are the presence of a rudimentary second caecum in *Cyclosalpa virgula,* the greater forward bending of the distal portion of the intestine in *C. virgula,* and the flattened instead of cylindrical form of the caecum in *Ritteria retracta.*

But, observe, our comparison here is between the solitary *Ritteria* and the aggregated *Cyclosalpa.* The aggregated Cyclosalpas, in three species, *virgula, bakeri,* and *floridana,* show a more or less coiled intestine. The solitary *Ritteria* shows a similar condition—that is, the aggregated *Cyclosalpa* and the solitary *Ritteria* diverge from the more archaic *Cyclosalpa* character toward that of other Salpidae. The solitary *Ritteria retracta* is not greatly modified in the character of its gut, but the aggregated zoöids, if known, would probably show a still more curved and compacted gut.

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[1] Ritter, 1906, *b*, fig. 2; Ihle, 1910, fig. 16, pl. 1.

The muscles of the solitary *Ritteria retracta* are numerous, the body muscles being 15 in number, as I would number them. Body muscles I to X are complete hoops, while body muscles XI to XV are interrupted ventrally, as is also the intermediate muscle. The oral muscles are distinctly of the *Cyclosalpa* type. There is a single oral retractor which passes outside the intermediate muscle. Apparently three sphincters are present in the lower lip, one of which (l_1), very wide, seems to lie on the incurved portion of the lip. There is in Ritter's figure a delicate, imperfect, first sphincter at the edge of the upper lip, at the angles of the mouth, and a second, very broad sphincter in the upper lip, of whose connections ventrally I am not quite sure from Ritter's figure, though it seems to connect with the second and third sphincters of the lower lip. Dorsal, horizontal muscle bands lie, one on each side, between this broad sphincter and the upper ends of the intermediate muscle, but are not connected with the latter. Ritter's dorsal and side views disagree as to the union of this horizontal band with the sphincter. The atrial muscles, likewise, are distinctly of the *Cyclosalpa* type, most resembling those of the solitary *C. virgula* in the character, position, and connections of both retractor and sphincters, but there is resemblance also to the aggregated *C. virgula* in the fact that all the distal atrial sphincters are connected with the retractor.

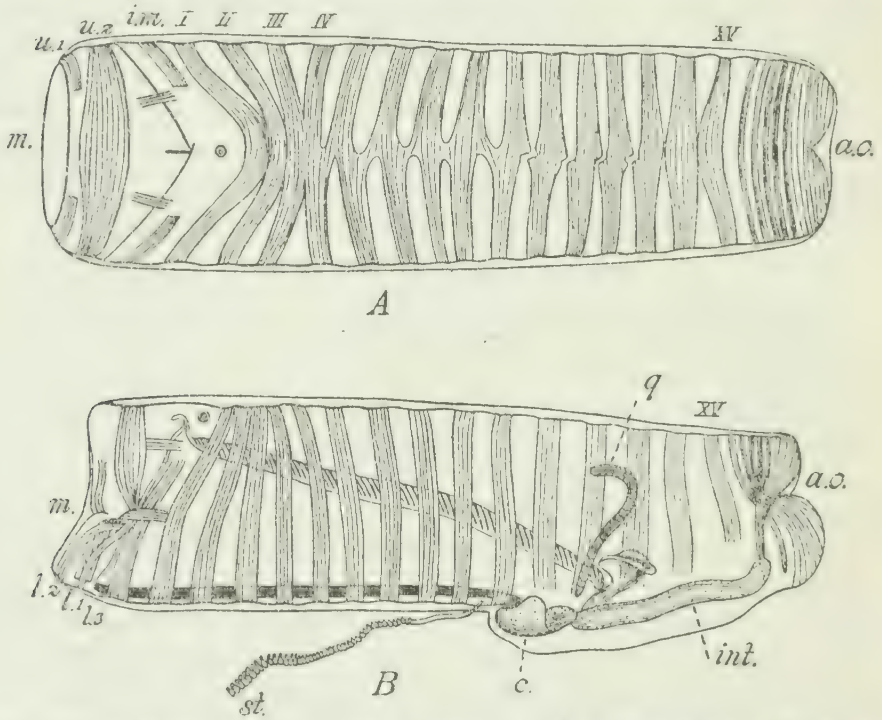

Fig. 25.—Ritteria retracta, solitary form: *A*, dorsal view; *B*, view from the left side. × 1¾ diameters. From Ritter (1906, *b*).

In the elongation of the body and the large number of the body muscles, the Ritterias have passed distinctly away from the *Cyclosalpa* condition.

The aggregated form of *Ritteria retracta* is unknown, except from one inadequate figure by Apstein (1906, *b*) of a small individual from the stolon of what he took to be "*Salpa amboinensis*," but which Ihle (1910) showed to be of the species *retracta*. No description of the aggregated zooid accompanies this figure, but it is sufficient to indicate close resemblance to the aggregated form of *Ritteria amboinensis*.

Apstein (1906, *b*) describes as *Salpa amboinensis* a form which, as Ihle (1910) has pointed out, is clearly Ritter's *retracta*.

RITTERIA PICTETI (Apstein, 1904).

Salpa picteti APSTEIN, 1904, *a*.

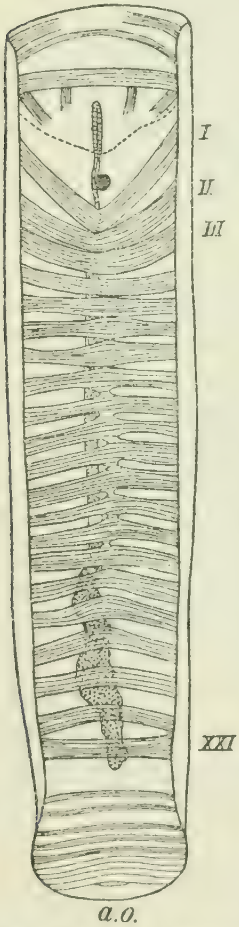

FIG. 26.—RITTERIA PICTETI, SOLITARY FORM, DORSAL VIEW. × 2 DIAMETERS. FROM APSTEIN (1904).

We have not as complete knowledge of this species as of *Ritteria retracta*, no description o the oral or atrial muscles, as seen in side view, being given. Apstein's figures (1904 and 1906, *a*) of dorsal and ventral views (figs. 26 and 27) show in one specimen 21 body muscles (Apstein, 1904), the presence of an incomplete intermediate muscle as in *R. retracta* not being quit certain from either the figures or descriptions. All are interrupted ventrally (fig. 27). In a second specimen, collected by the Deutsche Tiefsee-Expedition, Apstein (1906, *a*) shows 26 body muscles (fig. 27), there being here the same doubt as to the presence of an incomplete intermediate muscle. If I interpret him correctly, Ihle's description (1910) of his single specimen of this form indicates the presence of an incomplete intermediate muscle, which, like the body muscles, is interrupted ventrally. Ihle's specimen had 24 body muscles on the right side and 25 on the left.

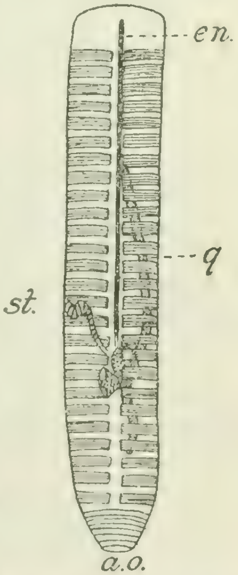

FIG. 27.—RITTERIA PICTETI, SOLITARY FORM, VENTRAL VIEW, NATURAL SIZE. FROM APSTEIN (1906, *b*).

Little can be said of the oral and atrial muscles except that, as figured by Apstein, there are three sphincters in the upper lip and that Ihle mentions the presence of an oral retractor stretching back to the first body muscle.

Ihle's figure (1910, fig. 16, pl. 1) of the gut (our fig. 28) shows conditions exactly paralleling what Ritter (1906, *b*) shows for *Ritteria retracta*, except that the caecum is apparently not flattened, as Ritter shows it for *R. retracta.* Apstein's best figure of the gut (1904, fig. 13, pl. 12), though not his description, while less clear, agrees with Ihle's description.

Ritter found in *Ritteria retracta* a problematic organ ("x") protruding on the left side of the body from near the junction of esophagus, intestine, and caecum (fig. 25 *B*, *q*, p. 54). He says: "A delicate strand seems to pass off from near its tip [base] toward the intestine." Apstein (1904 and 1906, *a*) shows for *Ritteria picteti* a probably similar organ, which he calls a glandular appendix of the intestine (fig. 27, *q*). Ihle finds a shorter, stockier body in a similar position, calling it a blood-forming organ (fig. 28, *q*). Its nature and function are in doubt, but its presence emphasizes the close resemblance between *Ritteria picteti* and *R. retracta.* This mass of cells, of problematic function, in these two species, is probably homologous with the more or less well-developed masses or groups of "eleoblast-like"[1] cells we have described in this paper for several species of *Cyclosalpa* (pl. 10, fig. 25, *q;* pl. 13, fig. 33, tip of caecum). The function and interpretation of these cells can not well be discussed without knowing their embryonic origin.

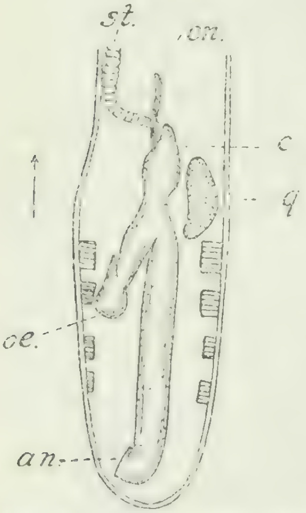

FIG. 28.—RITTERIA PICTETI, SOLITARY FORM, VENTRAL VIEW OF POSTERIOR END. × 2 DIAMETERS. FROM IHLE (1910).

The only noteworthy differences between *Ritteria picteti* and *R. retracta,* so far as our knowledge of them goes, are the larger number of body muscles in *R. picteti* and the interruption of all of them on the ventral side. These features, especially the latter, leave no doubt of the distinctness of the species.

The aggregated form of *Ritteria picteti* is unknown.

RITTERIA AMBOINENSIS (Apstein, 1904).

Salpa amboinensis APSTEIN, 1904, not 1906, *b*.
S. amboinensis IHLE, 1910.

Apstein (1904) and Ihle (1910) have studied this species. I have had 11 specimens of the solitary form, but no well-grown aggregated zoöids. Dober (1912) gives a figure of a form which he names *Salpa amboinensis*, but from the character of the intestine, only faintly delineated, it seems to be *Ritteria retracta*. Both solitary and chain forms of *R. amboinensis* are known. As Ihle has shown, it is clearly distinct from *R. retracta*, though the musculatures of the solitary forms of the two species are very much alike. The gut is very different in the two.

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[1] This resemblance to eleoblast tissue is in histological appearance only. It is not intended to suggest that there is any homology with eleoblast cells.

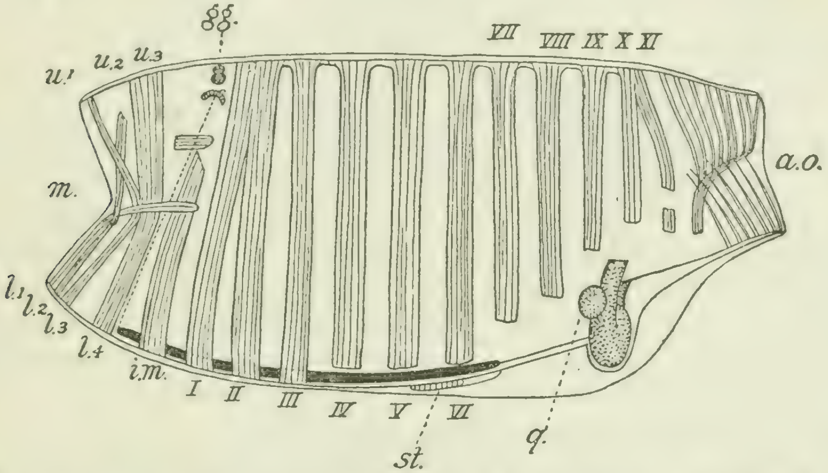

FIG. 29.—RITTERIA AMBOINENSIS, SOLITARY FORM, VIEWED FROM THE LEFT SIDE. × 5 DIAMETERS. FROM IHLE (1910). THE ORAL MUSCLES ARE SLIGHTLY CHANGED FROM IHLE'S DRAWING

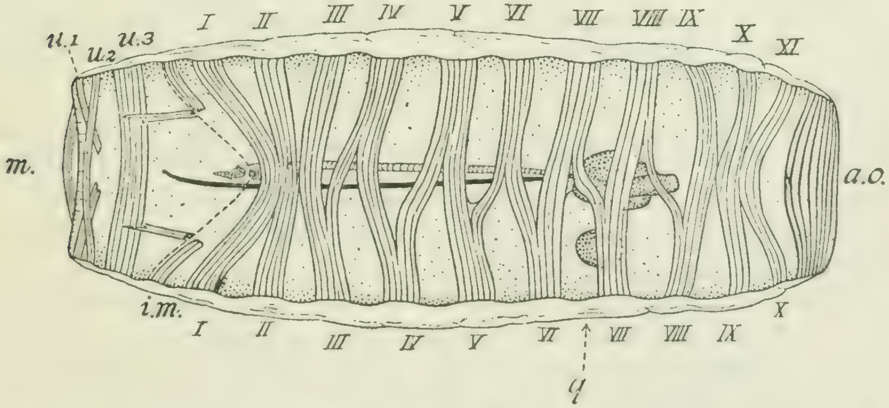

FIG. 30.—RITTERIA AMBOINENSIS, SOLITARY FORM, DORSAL VIEW. × 4½ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

RITTERIA AMBOINENSIS, solitary form.

Ihle's figure of a left side view of this form (fig. 29) can best be used for comparison with the other Ritterias. Compare also our figure of a dorsal view (fig. 30).

There are 10 to 13 body muscles and a dorsally incomplete intermediate muscle. According to Apstein (1904), in the embryo the intermediate muscle is complete dorsally, being united to body muscle I (see fig. 30, which shows a different condition in the adult). The intermediate muscle and the anterior three body muscles are continuous across the ventral mid line; the others are interrupted ventrally. The atrial retractor and its connected sphincters exactly resemble those of *Ritteria retracta,* but the strong basal sphincter of the latter species seems to be missing in *R. amboinensis.* There is close resemblance between these two species in the oral muscles also. The oral retractor lies external to all but the first of the muscles which it crosses. Ihle shows it external to this muscle also. It connects in front with the first sphincter of the lower lip and gives some fibers into the second lower lip sphincter also. Most of the fibers of this sphincter muscle pass on, outside the oral retractor, to form the first sphincter of the upper lip. The first sphincter of the upper lip and the second of the lower lip are thus connected, while the second sphincter and the very broad third sphincter of the upper lip continue below into the third and fourth sphincters of the lower lip. The oral retractor does not quite connect with body muscle I. The dorsal, horizontal band between the last sphincter of the upper lip and the intermediate muscle is as in *Ritteria retracta,* being connected with neither.

The gut is a vertical loop, moderately compact, with the anus at the left of the esophageal opening. No caeca show, but the part of the intestine into which the esophagus opens is enlarged, seemingly something as in the aggregated zoöid of *Cyclosalpa floridana* (fig. 15, pl. 5). The problematic organ, named by Ihle a blood-forming organ, is present at the left of the intestine (*q*, fig. 29), in a position similar to that occupied by the base of the corresponding organ in the other Ritterias. This organ is elongated cylindrical in *Ritteria retracta,* shorter and approaching globular in Ihle's specimen of *R. picteti,* and nearly spherical in *R. amboinensis.* In our specimens it is slightly larger than in Ihle's.

The position of these problematic organs, near the intestine, and what we know of their histology (Ritter), suggests their homology with the structure at the tip of the caecum in the aggregated zoöids of *Cyclosalpa bakeri* (pl. 10, fig. 25, *q*) and *C. virgula* (pl. 12, fig. 30). We thus have an instance of the appearance in the solitary Ritterias of a feature found among the Cyclosalpas in the aggregated zoöids only. The most noteworthy feature in the solitary *Ritteria amboinensis* is the looped character of the intestine, which is approaching the "nucleus" condition.

There is in the National Museum one lot of specimens, Cat. No. 6457, U.S.N.M. (solitary form) *Albatross* station D 5530, Balicasag Island, between Siquijor and Bohol Islands; August 11, 1909; surface; surface temperature, 84° F.; 3 + specimens.

RITTERIA AMBOINENSIS, aggregated form.

The aggregated form of this species is known from the studies of Apstein (1904) and Ihle (1910). Ihle's figures and description are much the fuller and will be used here. The shape of the zoöids in side view (fig. 31) is very like that of the aggregated *Cyclosalpa bakeri* (pl. 8). In dorsal view (fig. 33, *B*) or ventral view (figs. 32 and 33, *A*) it resembles *Salpa maxima* (fig. 67, p. 85). The aggregated *Apsteinia* magalhanica (fig. 63, p. 82) and *Ritteria hexagona* fig. 41, p. 67) have somewhat the same shape in dorsal view.

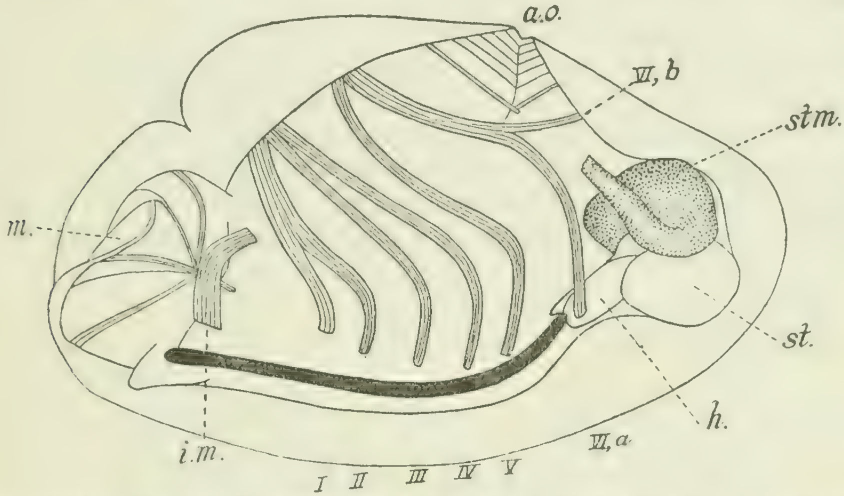

FIG. 31.—RITTERIA AMBOINENSIS, AGGREGATED ZOOID, VIEWED FROM THE LEFT SIDE. × 11 DIAMETERS FROM IHLE (1910).

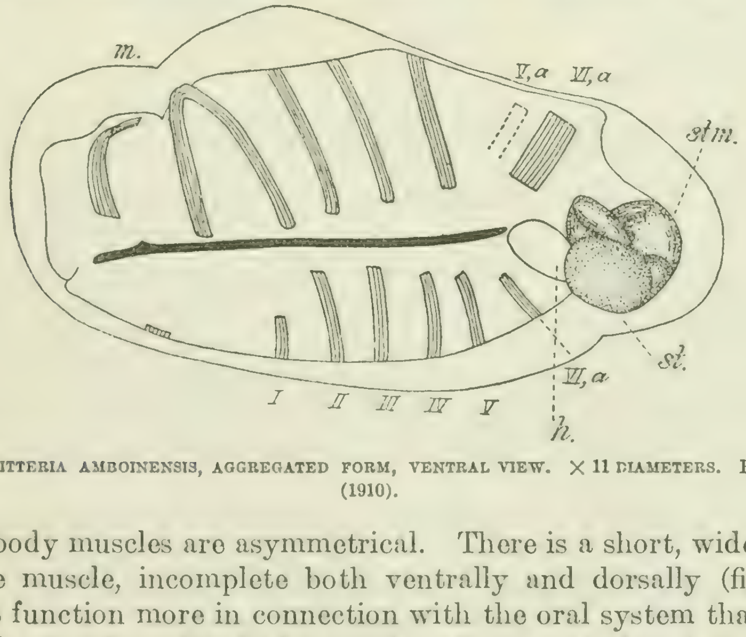

FIG. 32.—RITTERIA AMBOINENSIS, AGGREGATED FORM, VENTRAL VIEW. × 11 DIAMETERS. FROM IHLE (1910).

The body muscles are asymmetrical. There is a short, wide intermediate muscle, incomplete both ventrally and dorsally (fig. 31). It must function more in connection with the oral system than with the body muscles. Six body muscles are present, I and II united throughout the dorsal half of their course, III and IV converging to meet them on the dorsal surface, making a broad common trunk. Similarly V and VI unite dorsally into one broad muscle. Muscle VI has an anterior branch in front of the gut and a posterior branch which joins its fellow of the other side at the base of the atrial siphon, giving rise here, on the midline, to a median muscle, which runs into the base of the postabdomen (fig. 33, *B*). This is clearly the homolog of the visceral muscle we have emphasized in our description of the aggregated Cyclosalpas. No muscles are described arising from the lower part of the anterior branch of body muscle VI and passing into the post abdomen, this agreeing with the aggregated *Cyclosalpa virgula*. Just above its point of branching, body muscle VI connects with the well-developed atrial retractor muscle. In an older zoöid Ihle shows the atrial sphincter distinct at its base from body muscle VI. Body muscle VI corresponds closely in its position, branches, and connections with body muscle III of *Cyclosalpa floridana* and body muscle IV of the other Cyclosalpas. In the solitary forms of the Ritterias there is an increase in the number of body muscles. The same is seen to be true of the aggregated zoöids in *R. amboinensis* and it is also true of the aggregated form of *R. hexagona* (fig. 41, p. 67), these being the only species of *Ritteria* whose aggregated zoöids are known.

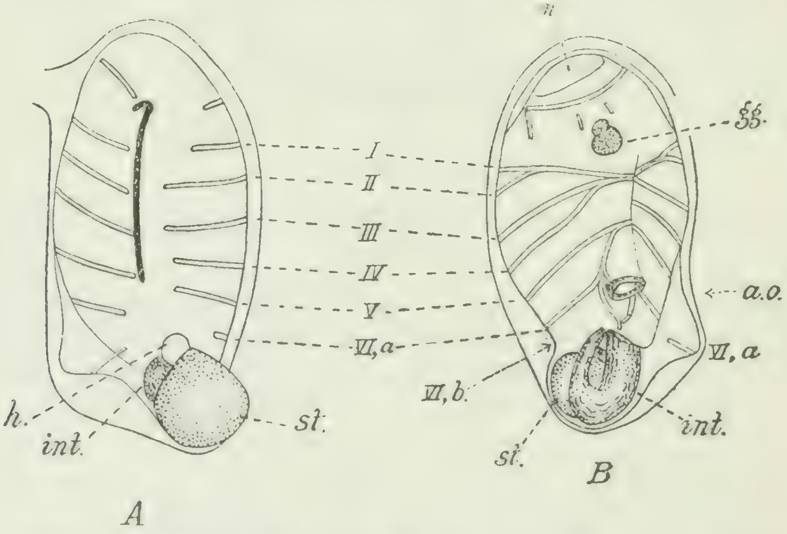

FIG. 33.—RITTERIA AMBOINENSIS, YOUNG AGGREGATED ZOOID FROM THE STOLON: *A*, DORSAL VIEW; *B*, VENTRAL VIEW. × 49 DIAMETERS. FROM IHLE (1910).

On the right side the arrangement of the body muscles is slightly different (figs. 32 and 33 A), but their number is the same. There is considerable asymmetry, both at their dorsal and their ventral ends, between the body muscles of the right and left sides. At the base of a postero-lateral protuberance[1] from the body is an unconnected broad muscle which probably should be included among the body muscles (fig. 32). No corresponding muscle is known in other Ritterias or in the Cyclosalpas.

The atrial muscles (fig. 31) resemble those of the aggregated *Cyclosalpa bakeri*, the distal delicate sphincters being connected (doubtless on each side) with a delicate retractor, a distinct stronger retractor being connected with the broad basal sphincter (fig. 33, *B*). In the aggregated *Cyclosalpa bakeri* this basal retractor is present only on the left side. The descriptions and figures of the aggregated *Ritteria amboinensis* do not include the atrial muscles of the right side.

The oral muscles (fig. 31) include a retractor and, in the upper and lower lips, two sphincters each, the details of whose connections are not figured or described. Ihle shows the oral retractor internal to the broad intermediate muscle (his "*Bogenmuskel*"). Such an arrangement is not known in other Salpidae except in the aggregated *Cyclosalpa floridana*.

The gut of the aggregated *Ritteria amboinensis* (fig. 31) is very similar to that of the solitary form. It is a loop with the wide esophageal aperture on the right and the anus above it on the left. At the point of union of esophagus and intestine there is a large rounded swelling on the left side (fig. 33, *B*, *st*), which Ihle calls the "stoloblast" or "eleoblast."[2] Its connections are not clearly shown and its nature is doubtful. It may correspond to the problematic organ "*q*" found in a similar position in the solitary form (fig. 29) or it may be a caecum, though, if it were either, Ihle, whose work is so uniformly accurate, would naturally have so described it. The gut is a little more compact in the aggregated zoöid than in the solitary form. It could perhaps be called a "nucleus."

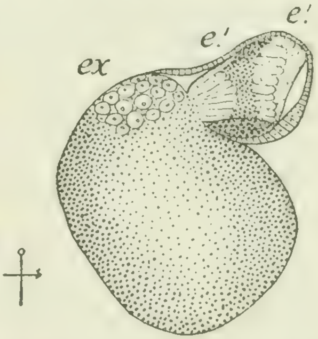

FIG. 34.—RITTERIA AMBOINENSIS, EYE AND GANGLION OF AN AGGREGATED ZOÖID. × 150 DIAMETERS. FROM APSTEIN (1904).

The eyes of the aggregated *Ritteria amboinensis* (fig. 34) are figured by Apstein (1904) with sufficient detail to allow some comparison with other species. The larger dorsal eye shows the anterior and posterior divisions characteristic of the true Salpas. In the posterior region the rod-cells are dorsal to the pigment; in the distal region they are ventral. One familiar with the eyes of other species must doubt the accuracy of Apstein's drawing, as to the arrangement of the rod-cells in the basal portion of the eye. They probably should lie with their long axes more nearly vertical. Behind the large dorsal eye, in the upper part of the ganglion, is an accessory mass of optic cells, very similar to that seen in the aggregated forms of *Salpa cylindrica* (figs. 87, p. 98, and 89, p. 99), *S. fusiformis* (fig. 79, p. 92), and *Apsteinia punctata* (figs. 56, p. 77, and 57, p. 78).

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[1] Right or left according to the position on the stolon (Ihle).

[2] Of course the aggregated zooid has no stolon rudiment and no eleoblast.

RITTERIA HEXAGONA (Quoy and Gaimard, 1824).

Salpa hexagona QUOY AND GAIMARD, 1824.
(?) *S. biennis* DE BLAINVILLE, 1827.
Iasis hexagona HERDMAN, 1891.

This species is somewhat unlike the other Ritterias, and the appropriateness of its inclusion in the same subgenus is perhaps doubtful. The numerous wide irregularly united muscle bands and the loosely looped gut, in the solitary form, and the rather decided asymmetry of the aggregated zoöids have, however, seemed sufficient to justify such classification.

I have abundant material of both solitary and aggregated forms of this species which has been studied by a number of zoologists. Streiff, who has done such accurate work on the muscles of many species, has not observed this form. The drawings here given are after Traustedt (1885) and Apstein (1894, *b*) and from specimens in the collections of the United States Bureau of Fisheries and the United States National Museum, which include many individuals of both solitary and chain forms from Philippine waters and the northern Pacific Ocean off Alaska.

The following specimens are in the collection of the United States National Museum:

Cat. No. 6428, U.S.N.M. (solitary form), *Albatross* station D 5258, Juraojurao Island, off southern Panay; June 2, 1908; surface; surface temperature, 84° F.; surface density, 1.02587; one specimen.

Cat. No. 6458, U.S.N.M. (embryo), *Albatross* station D 5128, Nogas Island, Sulu Sea; February 4, 1908; surface; surface temperature, 80° F.; one specimen.

Cat. No. 6455, U.S.N.M. (aggregated form), *Albatross* station D 5196, Capitancillo Island, off northern Cebu Island; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; three specimens.

Cat. No. 6516, U.S.N.M (aggregated form), *Albatross* station D 5128, Sulu Sea, vicinity Southern Panay, Philippine Islands, February 4, 1908; surface; surface temperature, 80° F.; 60 plus specimens.

Cat. No. 6531, U.S.N.M. (solitary form), *Albatross* station D 5350, Palawan Passage, Philippine Islands; December 27, 1908; surface; surface temperature, 80° F.; surface density, 1.02381; one specimen.

Cat. No. 6539, U.S.N.M. (aggregated forms), *Albatross* station D 5128, Sulu Sea, vicinity southern Panay, Philippine Islands; February 4, 1908; surface; surface temperature, 80° F.; three specimens.

Cat. No. 6570, U.S.N.M. (aggregated form), *Albatross* station D 5175 Sulu Sea, Southeast of Cagayanes Islands, Philippine Islands; March 8, 1908; surface; surface temperature, 82° F.; 100 + specimens.

Cat. No. 6590, U.S.N.M. (solitary form), *Albatross* station D 5616, Molucca Passage, Philippine Islands; November 22, 1909; surface; surface temperature, 84° F.; one specimen.

Cat. No. 6591, U.S.N.M. (chain form), *Albatross* station D 5128, Sulu Sea, vicinity southern Panay, Philippine Islands; February 4, 1908; surface; surface temperature, 80° F.; 15 + specimens.

Cat. No. 6592, U.S.N.M. (aggregated form), *Albatross* station D 5186, between Panay and Negros, Philippine Islands; March 30, 1908; surface; surface temperature, 80° F.; surface density, 1.02530; 25 + specimens.

Cat. No. 6611, U.S.N.M. (aggregated form), *Albatross* station D 5234, between Bohol and Leyte, Philippine Islands; May 7, 1908; surface; surface temperature, 84° F.; surface density, 1.02531; 36 specimens.

Cat. No. 6621, U.S.N.M. (solitary form), *Albatross* station D 5601, Gulf of Tomini, Celebes; November 13, 1909; surface; surface temperature, 83° F.; two specimens.

Cat. No. 6623, U.S.N.M. (aggregated form), *Albatross* station D 5437, W. coast of Luzon, Manila Bay to Lingayen Gulf; May 8, 1909; surface; surface temperature, 86° F.; one specimen.

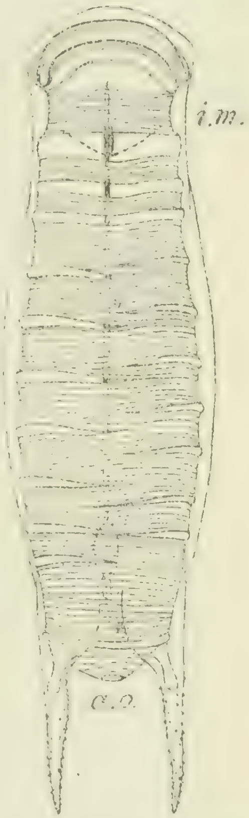

FIG. 35.—RITTERIA HEXAGONA, SOLITARY FORM, DORSAL VIEW. FROM TRAUSTEDT (1885).

RITTERIA HEXAGONA, solitary form.

The very broad body muscles are irregularly continuous across the mid-dorsal line, but are widely interrupted ventrally (fig. 35). Their disposition is not identical on the right and left sides. At the posterior end of the body the body muscles form an almost complete layer, the degree of antero-posterior fusion between the successive muscle bands differing in different individuals, so one can not say how many such bands are typically present. Among my specimens I find individuals showing 9 on one side and 10 on another; 10 on each side; 10 on one side and 11 on the other; 11 on each side; 11 on one side with 12 on the other; and, in one of the largest specimens, 12 on each side.

The intermediate muscle (*i. m.*) seems to be the very broad band which lies across the dorsal surface, in front of the ganglion (fig. 36).

The upper lip bears a broad third sphincter with a very delicate second sphincter branching from its base and a rather narrow admarginal sphincter attached at its base to both the oral retractor and the third dorsal sphincter. The lower lip has a rather narrow admarginal sphincter, continuous at each angle of the mouth with a rudimentary oral retractor muscle whose unconnected posterior end lies horizontally between the intermediate muscle and body muscle I. A broad second sphincter lies near the base of the incurved flap of the lower lip.

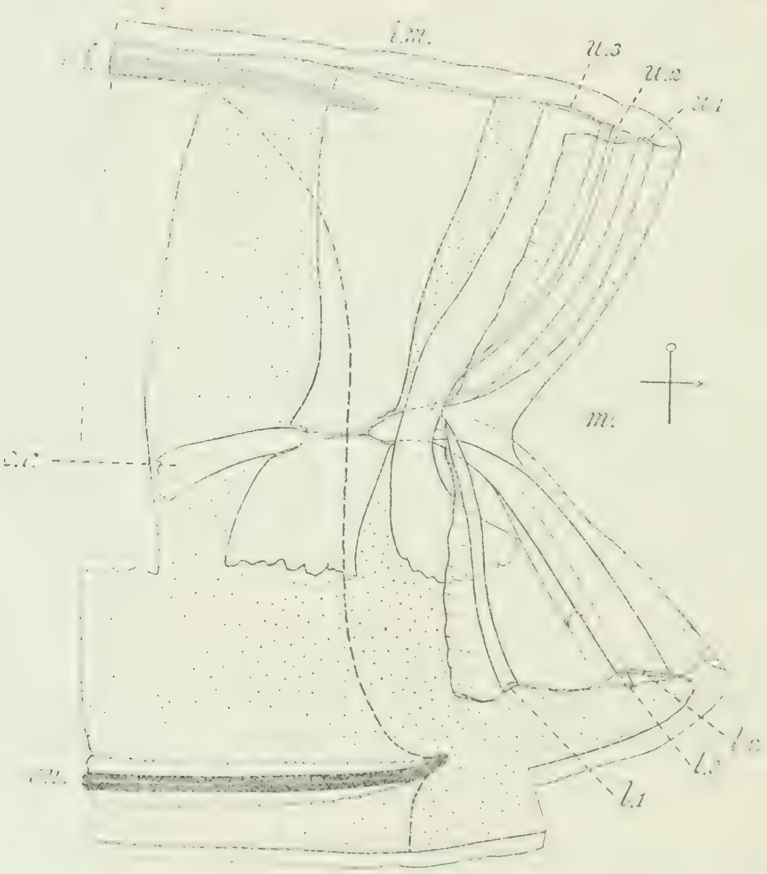

FIG. 36.—RITTERIA HEXAGONA, SOLITARY FORM, ORAL MUSCLES OF THE LEFT SIDE, SEEN FROM THE INSIDE × 5 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

A third sphincter arises from the oral retractor in front of the second. It is at first broad, but soon narrows to a thread, which lies just beneath the second sphincter, that is, on the endodermal side of the incurved flap. Both lips are seen to be incurved, the ventral more strongly than the dorsal. There are no horizontal muscles lying between the basal oral sphincter and body muscle I, as there are in most species.

On each side of the body, posteriorly, is a well-developed horizontal atrial retractor muscle (fig. 37) continuous with the very numerous strands of the atrial sphincters, which are so close together that they seem to form a broad band continuous over both lips of the atrial aperture. The fibers of this atrial sphincter are less closely approximated than are those composing one of the body muscles, the fibers not actually touching side by side in the former while they do in the latter.

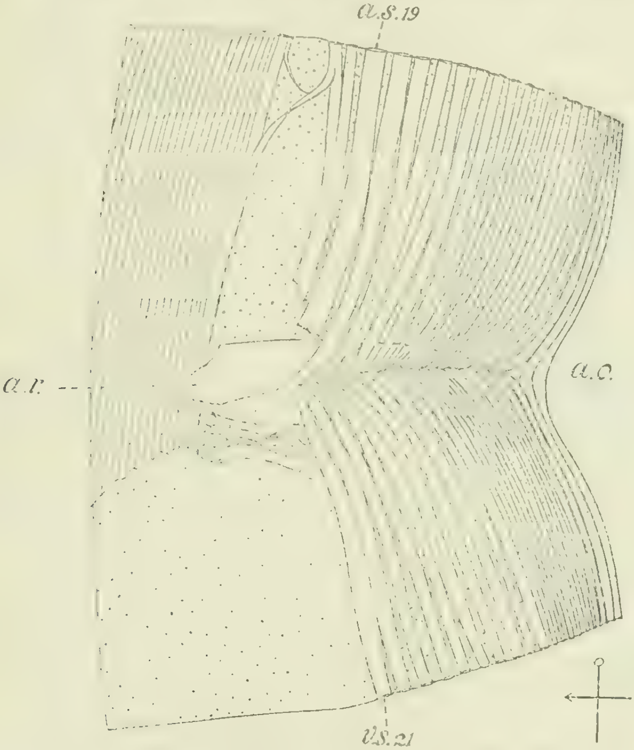

FIG. 37.—RITTERIA HEXAGONA, SOLITARY FORM, ATRIAL MUSCLES, VIEWED FROM THE LEFT SIDE. ×5 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

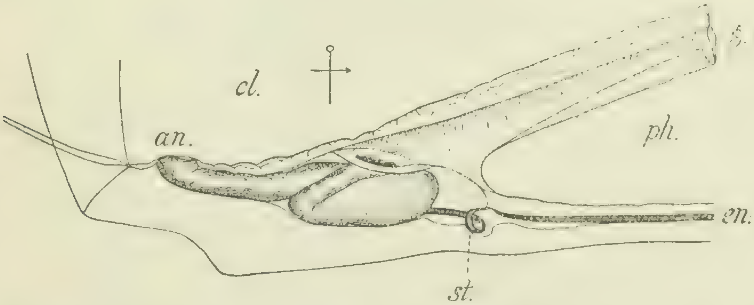

FIG. 38.—RITTERIA HEXAGONA, SOLITARY FORM, THE GUT VIEWED FROM THE RIGHT SIDE. ×3⅓ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

Ventral to the base of the atrial retractor muscle are several branching muscle strands not observed in other species.

The gut (fig. 38), as in the other solitary Ritterias, is a simple loop. In *R. hexagona* there is a bend where the esophagus enters the intestine, the first portion of the intestine lying along the esophagus. The distal, free end of the intestine extends back, as in *Ritteria retracta*, and *R. picteti*, to open a little in front of and below the atrial aperture.

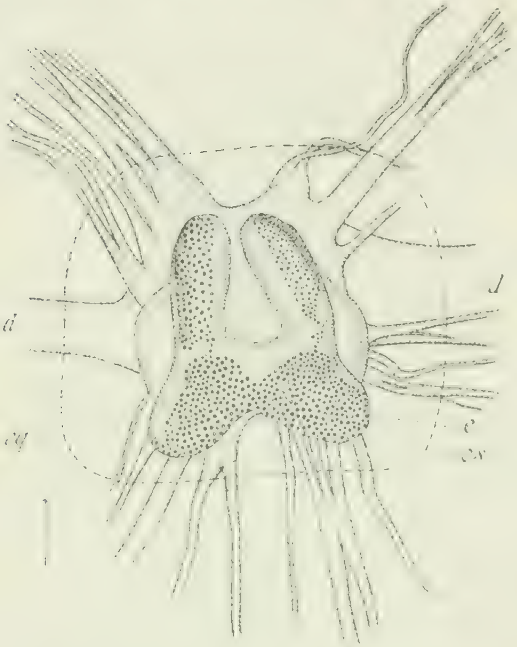

FIG. 39.—RITTERIA HEXAGONA, SOLITARY FORM, DORSAL VIEW OF EYE AND GANGLION; × 58 DIAMETER.

The condition of the neural glands and eye (fig. 39) in the solitary *Ritteria hexagona* has not heretofore been described. The disks of the gland are well developed (fig. 40). Their ducts (*d*) are peculiar. Instead of being a narrow coiled tube, as in other species, each duct is very wide, its diameter being nearly half as great as that of the discoidal gland itself, and its aperture to the pharyngeo-cloacal chamber being of the same width as the duct. There are no distinct outgrowths from the ganglion in connection with the glands, though one sees a broad protuberance (*b*) of the ganglion where each gland touches it. The cells in these protuberances are like the ordinary smaller cells of the ganglion.

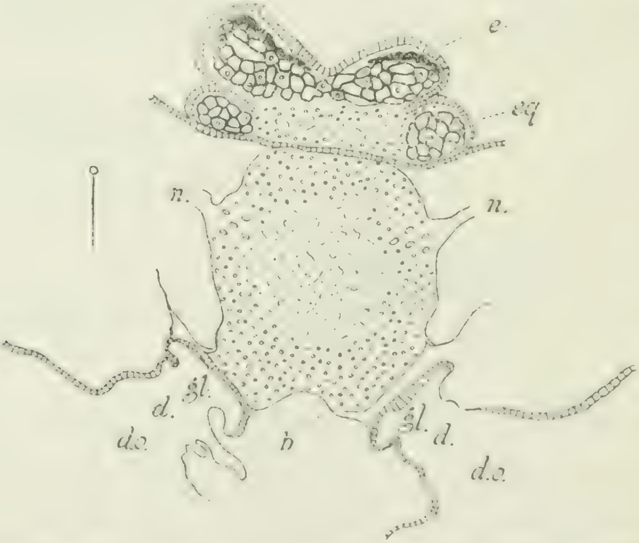

FIG. 40.—RITTERIA HEXAGONA, SOLITARY FORM, TRANSVERSE SECTION OF EYE, GANGLION AND NEURAL GLANDS. × 47 DIAMETERS.

The horseshoe form of the eye (fig. 39) is modified in this species, the postero-lateral regions of the horseshoe being drawn upward, making quite an angle, these regions being also enlarged.

The rod-cells (fig. 40) are degenerate angular cells with irregularly thickened walls, as in the solitary *Salpa fusiformis* (fig. 79, p. 92). Below the main mass of the horseshoe, on each side, is a secondary mass (*eq*) of similar irregular rod-cells with no associated pigment.

There are a pair of conical, denticulate protuberances (fig. 35) from the postero-lateral angles of the body, somewhat similar to those of *Thalia longicauda* (fig. 113, p. 120) and *Thetis vagina* (fig. 114, p. 122). Into the base of each runs a tube of mantle epithelium.

RITTERIA HEXAGONA, aggregated form.

The aggregated zoöids of this species (fig. 41) are quite strongly asymmetrical, but the asymmetry affects chiefly the test, which has an angular protuberance at one side of the posterior end of the body.

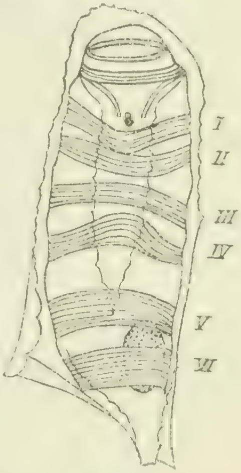

FIG. 41.—RITTERIA HEXAGONA, AGGREGATED ZOÖID, DORSAL VIEW. × 2 DIAMETERS. FROM APSTEIN (1894, *b*).

As in the solitary form, the muscle bands are broad and strong, and the test very firm. There are six body muscles, continuous across the dorsal mid line, but widely interrupted ventrally. The intermediate muscle (*i. m.*, fig. 42) shows a condition which aids us in interpreting the relations in the solitary form. There is a broad band (*i. m.*) continuous across the mid-dorsal line, and branching obliquely backward from this on each side is a narrower band of muscle ($i. m._2$), whose posterior end approaches but does not touch the dorsal region of body muscle I. These oblique bands are apparently the intermediate muscles. The broader band, on the other hand, which is continuous across the dorsal mid line, is the apparent homolog of the muscle which in the solitary *Ritteria hexagona* we called the intermediate muscle. Apparently, in the aggregated zoöids of this species, the intermediate muscle is double, the posterior division being oblique and discontinuous dorsally, the anterior division lying more vertical and being continuous across the dorsal line. In a number of the more aberrant species of Salpidae the intermediate muscle is double.

The oral retractor muscle on each side is very short and broad (fig. 42). It bifurcates in front, the dorsal branch being continued into the first sphincter of the upper lip. In the upper lip are a second narrow sphincter and a third very broad. The lower end of the second sphincter abuts upon, but does not fuse with, the third sphincter; this third sphincter similarly abuts upon the oral retractor muscle without fusing with it. The ventral branch of the retractor muscle is continued into the very broad third sphincter of the lower lip. There are two other sphincter muscles in the lower lip, attached to the ventral branch of the retractor. The first of these, the admarginal sphincter, is of moderate width. The second is still narrower. Distally it fuses with the third sphincter. The dorsal horizontal bands, which in most species lie between the basal oral sphincter and the first body muscle, are wanting in this species.

There is an atrial retractor muscle on each side (fig. 43), internal to the sphincters, of which there are fourteen in each of several individuals studied. The basal two sphincters are broad and strong; sphincters 6 to 12 (numbering from the aperture) are attached to the ventral edge of the retractor. In sphincters 7 or 8 to 12 only part of the fibers bend and run into the retractor; other fibers pass across the retractor, making complete hoops. The distal five sphincters are not connected with the retractor muscle. The terminal three are very delicate. The fibers of the sphincter muscles, like those of the body muscles, form an even single layer. The fibers are flat, and lie edge to edge, presenting a perfectly regular appearance. The fibers of the retractor, on the other hand, are elliptical, not flat, in cross section, and are more irregularly arranged.

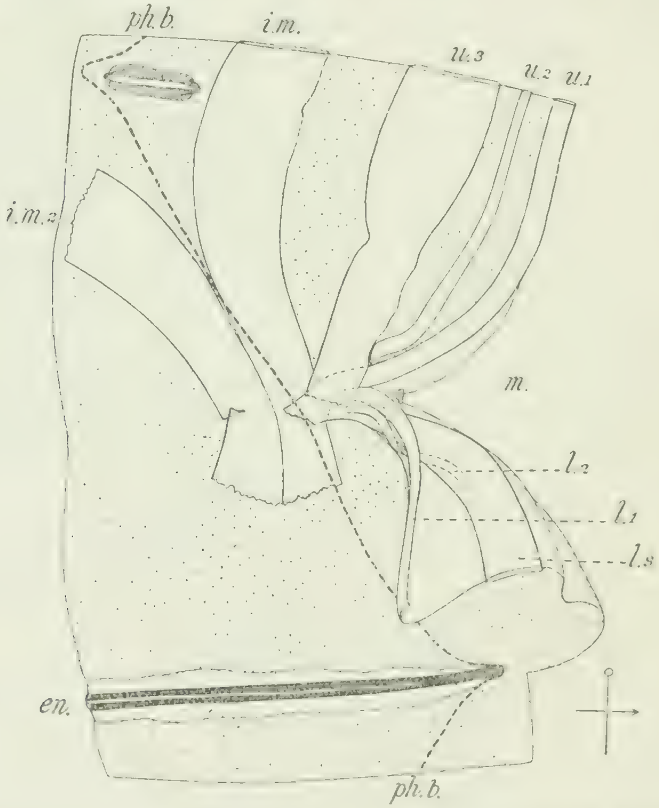

FIG. 42.—RITTERIA HEXAGONA, AGGREGATED FORM, ORAL MUSCLES OF THE LEFT SIDE SEEN FROM THE INSIDE. (DRAWN BY HOYT S. HOPKINS.)

In all the body muscles and in the wider atrial sphincters one fiber, or sometimes two or three fibers, at each edge of each muscle band are much broader than the rest of the fibers of the band. The more distal sphincters have their fibers, 2 to 10 in number, uniformly narrow. All the inner fibers in all the muscles are narrow.

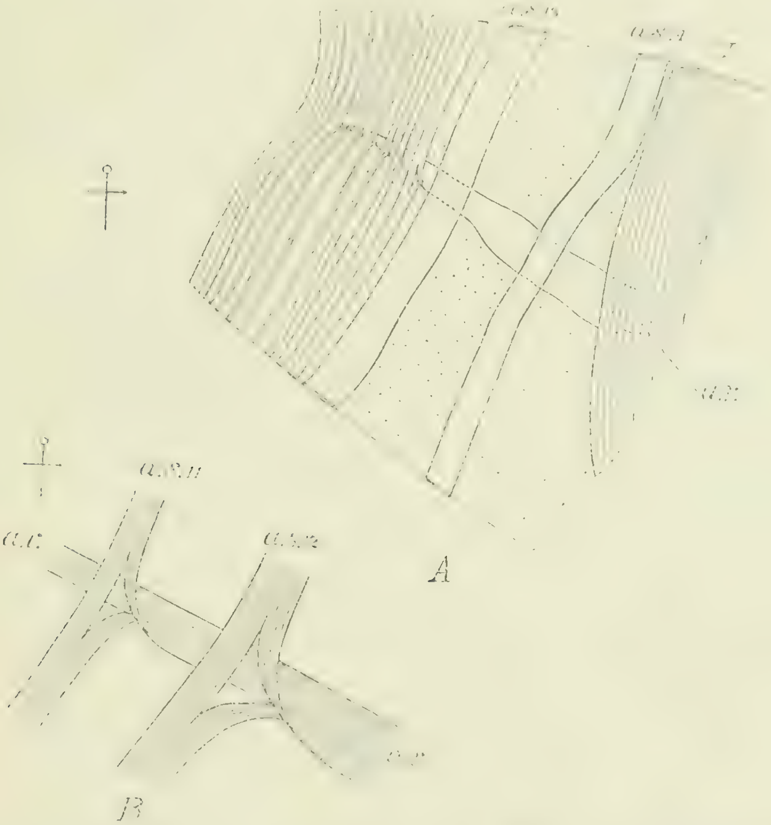

FIG. 43.—RITTERIA HEXAGONA, AGGREGATED FORM: *A*, ATRIAL MUSCLES VIEWED FROM THE RIGHT SIDE; *B*, DETAIL SHOWING ATTACHMENT OF THE SPHINCTERS TO THE ATRIAL RETRACTOR MUSCLE. (DRAWN BY HOYT S. HOPKINS.)

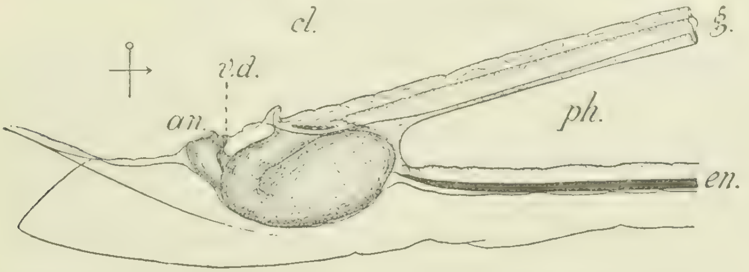

FIG. 44.—RITTERIA HEXAGONA, AGGREGATED FORM, GUT SEEN FROM THE RIGHT SIDE. × 3 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The gut (fig. 44) forms a somewhat compact "nucleus," as in the aggregated zoöids of *Ritteria amboinensis*, but the course of the intestine can be seen without dissection. Its condition is closely similar to that in the solitary form except that the intestine is shorter.

The large dorsal eye (figs. 45 and 46) resembles that of *Cyclosalpa virgula*, except for three points: First, the optic plug is wholly wanting, as is true of all species outside the subgenus *Cyclosalpa;* second, the rod-cells are very irregular and are evidently degenerate; third, the position of the eye with reference to the ganglion is different. In *Ritteria hexagona* the ganglion has rotated forward forty-five degrees, as is shown by the position of the zone of large cells from which the nerves arise (*z.* in fig. 46). The originally dorsal surface is dorso-anterior. The eye is connected with the originally anterior part of the originally dorsal surface [now the dorsal part of the anterior surface], as in all other species. A similar rotation is seen in *Apsteinia punctata* (fig. 57, p. 78), and is still more marked in *Thalia* (fig. 111, p. 117). The long axis of the eye in *Ritteria hexagona* stands at an angle of 45 degrees to the originally dorso-ventral axis of the ganglion. The same is true in *Salpa maxima* and *S. fusiformis* (fig. 79, p. 92). In the Cyclosalpas, on the other hand, the eye has bent forward until its long axis is nearly parallel to the antero-posterior axis of the ganglion. The Cyclosalpas retain the ganglion in its primitive position, but rotate the eye forward from 160° to 180° in different species. *Ritteria hexagona* and *Apsteinia punctata* (fig. 57) rotate the ganglion forward 45° and the eye rotates about 140° forward. *Thalia democratica* rotates the whole ganglion and eye forward nearly 180°. The position of the eye in relation to the body of the salpa is about the same in the aggregated zoöids of all species except the Thalias, Pegea, and the Traustedtias, but it is effected in some by the rotation of the eye alone; in others by the rotation of both eye and ganglion.

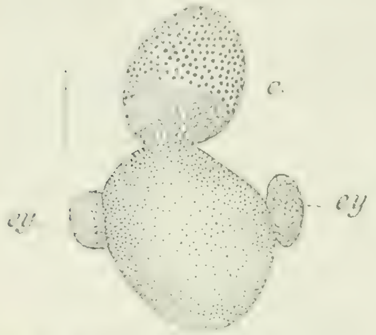

FIG. 45. RITTERIA HEXAGONA, AGGREGATED FORM, DORSAL VIEW OF GANGLION, EYE AND ACCESSORY EYES. × 100 DIAMETERS. FROM METCALF (1893, c).

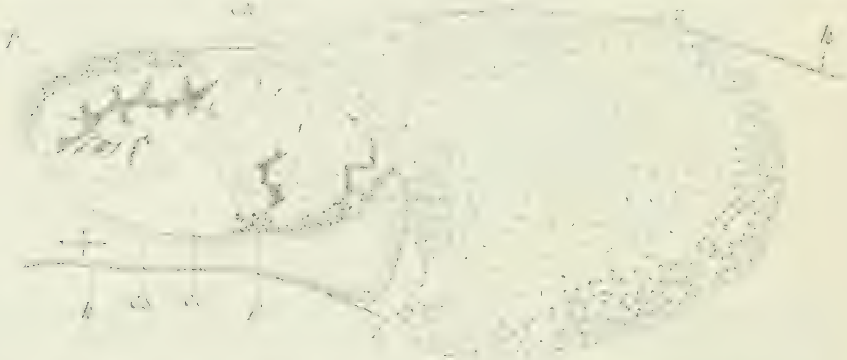

FIG. 46.—RITTERIA HEXAGONA, AGGREGATED FORM, SAGITTAL SECTION OF GANGLION AND EYE. × 150 DIAMETERS. FROM METCALF (1893, c).

There are no accessory eyes in the ganglion proper in the aggregated *Ritteria hexagona*, but there are a pair of outgrowths (*cy* in figs. 45 and 47), one on each side, near the dorsal surface of the ganglion, which contain cells closely resembling the degenerate rod-cells in the eyes of many species of Salpidae; as for instance, *Salpa fusiformis*, solitary, dorsal eye (fig. 76, p. 91), *S. fusiformis*, aggregated, accessory eye (fig. 79, p. 92), *Thetys vagina*, aggregated, dorsal and accessory eyes (fig. 118, p. 126), and *Pegea confederata* (figs. 126 and 127, p. 136, and 132, p. 143). No pigment is associated with these masses of degenerate rod-cells in *Ritteria hexagona*. The position of these outgrowths, just above the disks of the neural gland, suggests their homology with the large-celled outgrowths in other species.

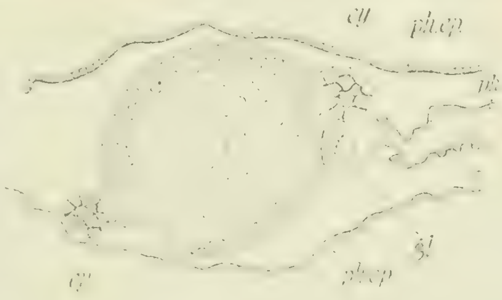

FIG. 47.—RITTERIA HEXAGONA, AGGREGATED ZOOID, OBLIQUE SECTION OF GANGLION SHOWING A BIT OF ONE OF THE NEURAL GLANDS (*gl.*) AND THE TWO LATERAL OUTGROWTHS (*cy.*) FROM THE GANGLION WITH THEIR CELLS DEVELOPED AS DEGENERATE ROD-CELLS. × 150 DIAMETERS. FROM METCALF (1893, c.).

The Ritterias show close similarity to one another in their muscular system, which is of the *Cyclosalpa* type, except that the body muscles are more numerous. In the character of the gut they are intermediate between the Cyclosalpas and the other Salpidae. In the asymmetry of the aggregated zoöid (in the three species in which the aggregated form is known) they resemble the *Cyclosalpae asymmetricales* and the Apsteinias. In fact some degree of asymmetry is observed in the aggregated zoöids of most species of Salpidae.

APSTEINIA, new subgenus.

It includes the species *punctata*, *asymmetrica*, and *magalhanica*.

The species *punctata* may be taken as the type of this subgenus, for it is the best known of the three species. We have had material of only *Apsteinia punctata*.[1] Other species have been studied by Apstein (1894, *b*), Fowler (1896), Dober (1912), and Streiff (1908).

This subgenus is characterized by the marked asymmetry of its aggregated zoöids, in which it agrees with the *Ritterias*, *Brooksia*, and some *Cyclosalpas*, and by the compact condition of the gut, which, in both solitary and aggregated forms of all species, forms a "nucleus," as in the higher Salpidae. The *Apsteiniae* differ from the *Salpae, sensu strictu*, in having all the body muscles in the solitary forms in the condition of complete hoops, as in *Doliolum*.

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[1] After this paper was in press material of *Apsteinia asymmetrica* was obtained. See Appendix, page 1[illegible]

APSTEINIA PUNCTATA (Forskål, 1775).

Salpa punctata Forskål, 1775.
S. punctata Vogt, 1854.
S. musculosa Herdman, 1888.

We have had for study four specimens of the solitary form of this species and five of the aggregated zoöids, besides the well-developed zoöids on the stolons of two of the solitary individuals. Specimens of both solitary and aggregated forms have been deposited in the United States National Museum.

Cat. No. 6463 U.S.N.M. (solitary form), from Naples Zoological Station; one specimen.

Cat. No. 6464, U.S.N.M. (aggregated form), from Naples Zoological Station; four specimens.

Careful comparison of our specimens has shown Streiff's work so accurate that for the musculature we use mostly his figures.

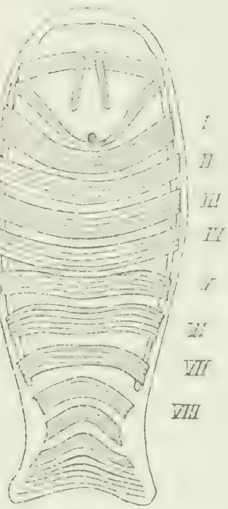

Fig. 48.—Apsteinia punctata, solitary form, dorsal view showing muscles. From Strieff (1908).

APSTEINIA PUNCTATA, solitary form.

There are eight body muscles (figs. 48 and 49), all broad complete bands except the eighth, which is interrupted ventrally at the sides of the gut, as the homologous muscle is in the Cyclosalpas and, of course, the Ritterias. The intermediate muscle and body muscles I and II are in contact dorsally. The edges of all the body muscles are composed of wide fibers (fig. 51). The central fibers are much narrower. The bands thus appear lighter on each edge.

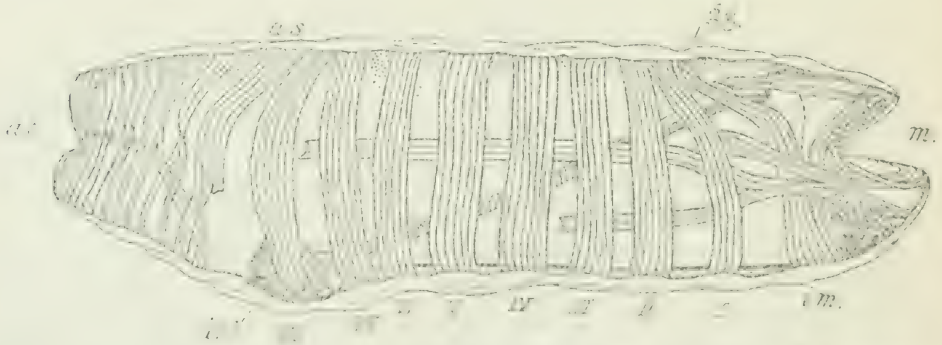

Fig. 49.—Apsteinia punctata, solitary form, viewed from the right side. ×2 diameters. (Drawn by Hoyt S. Hopkins.)

The oral muscles (fig. 51) include a dorsal retractor and a ventral retractor which posteriorly is bifurcated, its dorsal division running back along the side of the body in a horizontal plane, reaching beyond the posterior edge of the seventh body muscle (figs. 48 and 49). Its ventral division runs backward and a little ventralward, to the posterior edge of the third body muscle (fig. 49). In the lower lip there is a very short unconnected band (*l. 1*) at the edge of the lip (fig. 51), not before described, and a second, broad, sphincter (*l. 2*) not split as in the embryo Streiff figures (fig. 50), and continuous with the dorsal retractor. There is a third sphincter, not so broad as the last, continuous dorsally with the first sphincter of the upper lip. The dorsal retractor shows broad fibers on its edges, as does the main trunk of the ventral retractor. The two elongated posterior divisions of the retractor, on the other hand, do not show their marginal fibers broader than their central ones. The fourth sphincter of the lower lip is broad. Posteriorly it is continuous with the ventral oral retractor. Just in front of the intermediate muscle lies a very broad fifth sphincter of the lower lip, with broad marginal fibers.

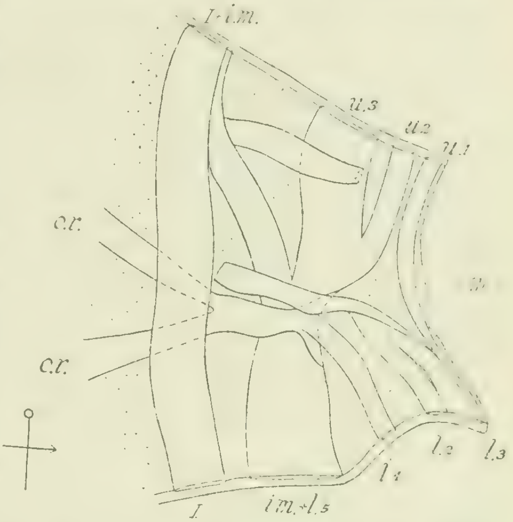

FIG. 50.—APSTEINIA PUNCTATA, EMBRYO, ORAL MUSCULATURE, VIEWED FROM THE RIGHT SIDE. FROM STREIFF (1908), MY LETTERING.

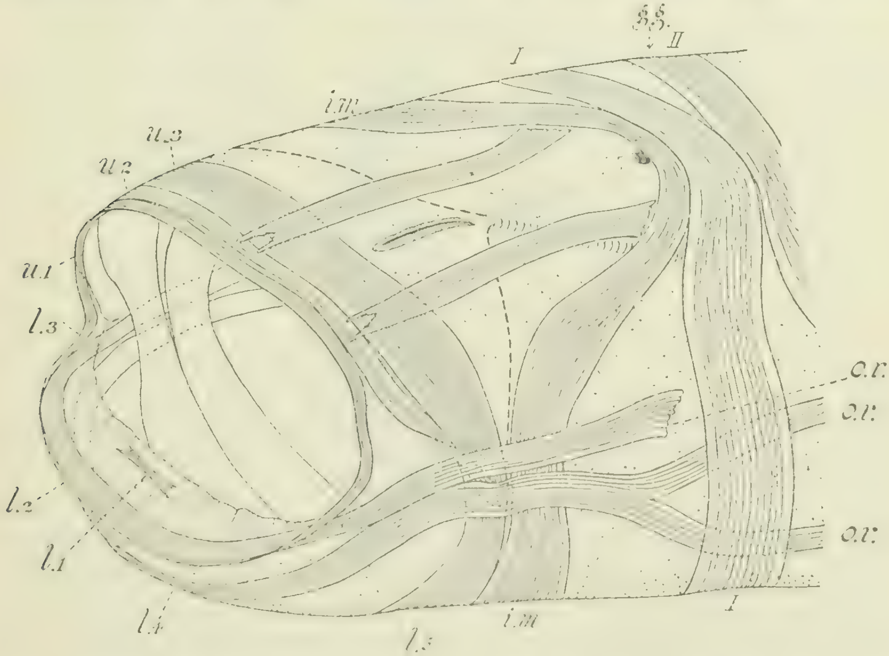

FIG. 51.—APSTEINIA PUNCTATA, SOLITARY FORM, ADULT. THE ORAL END OF THE BODY, ANTERO-LAEVODORSAL VIEW. × 5 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

In the upper lip there are, in the embryo figured by Streiff (fig. 50) and in two of our adults, three sphincters, one, moderately broad, at the edge of the lip, continuous ventrally with the posterior edge of the second sphincter of the lower lip, a second slightly broader sphincter, and a third, very broad, the latter continuous ventrally with the broad fifth sphincter muscle of the lower lip. The second sphincter of the upper lip twists and bends back, attaching to the inside of the ventral oral retractor. In two others of our adult specimens, sphincters 2 and 3 of the upper lip are united throughout their course, forming a very broad band. The dorsal retractor is external to all the muscles it crosses. The ventral retractor is external to the intermediate muscle, but both its posterior extensions are internal to all the body muscles they cross.

Streiff, in describing and figuring the conditions in his embryo, apparently made one slight error, failing to note the incurling of the edge of the lower lip, so that the muscles of the incurled portion of the lip are incorrectly given. The minute rudimentary first sphincter muscle he doesn't show. His first sphincter should be number three. That is, he has exactly reversed the space relations.

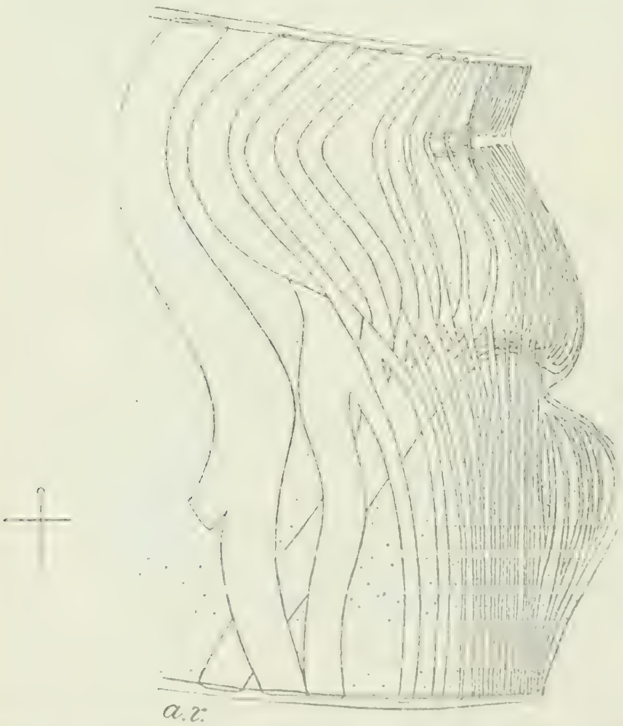

Fig. 52.—Apsteinia punctata, solitary form, atrial musculature, seen from the left side. From Streiff (1908).

The oral muscles of the solitary *Apsteinia punctata*, including the dorsal horizontal band between the intermediate muscle and the sphincters of the upper lip, are rather similar to those described for the Cyclosalpas and Ritterias, showing no important differences except the great posterior extension of the dorsal and ventral branches of the ventral oral retractor. This is a remarkable feature. Streiff, however, shows for the solitary form of *Cyclosalpa virgula* a ventral oral retractor which is split posteriorly into dorsal and ventral branches. These branches extend back only to the first body muscle. In our specimens of the solitary *Cyclosalpa virgula* the ventral oral retractor is undivided (pl. 11, fig. 26).

The atrial muscles, well shown by Streiff (fig. 52), conform to the condition seen in the solitary Ritterias and the solitary *Cyclosalpa virgula*, except that in the latter species the distal sphincters are not connected with the retractor (pl. 11, fig. 26) and in *Ritteria retracta* Ritter shows the atrial retractor external to the atrial sphincters (fig. 25, p. 54). Streiff describes, and our specimens show, a folding and interruption of the marginal sphincters dorsal to the atrial retractor.

Both lips of the solitary *Apsteinia punctata* bear the numerous delicate cylindrical branches of a gland (?) whose histological structure suggests that it may possibly be a phosphorescent organ (fig. 49). Its form, however, is very different from any known luminous organ in other species. Glands of similar appearance, though less developed, are on the lips of the aggregated zoöids. Behind the gut, and on each side of it, are similar branching glands in the solitary form.

The eye is in the condition usual in the solitary Salpidae.

APSTEINIA PUNCTATA, aggregated form.

This zoöid (fig. 53) is strongly asymmetrical, though not so much so as is the aggregated *Brooksia rostrata* (fig. 24, p. 52) or the aggregated *Cyclosalpa virgula* (pls. 11, 12, and 13). Its muscles are sufficiently indicated by the figures. In this species, as in *Brooksia rostrata*, there are dextral and laeval individuals.

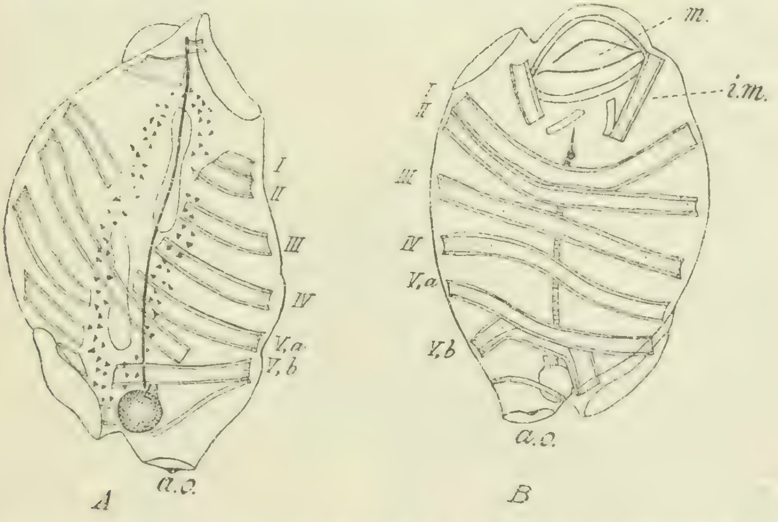

FIG. 53.—APSTEINIA PUNCTATA, AGGREGATED ZOÖID FROM THE LEFT SIDE OF THE STOLON: *A*, VENTRAL VIEW; *B*, DORSAL VIEW. FORM STREIFF (1908) WITH MODIFICATIONS.

The body muscles are five in number, the fifth being divided into the usual two branches seen in the aggregated zoöids of other species. On one side only of the body, a delicate branch arises from body muscle V *b* and runs to the region of the gut (fig. 53 *A*). This reminds one of the delicate branch in the aggregated zoöids of

Cyclosalpa affinis (pl. 3, fig. 10), *C. floridana* (pls. 4, 5, and 6), and *C. bakeri* (pls. 7, 8, 9, and 10), arising on each side of the body from the last body muscle, and running to the viscera. Note, however, that in these *Cyclosalpas* this delicate strand arises from the anterior branch of the last body muscle while in *Apsteinia punctata* it arises from the posterior branch of this muscle. All the body muscles are interrupted ventrally. The intermediate muscle is present on each side as a broad band, much longer on one side than the other. The oral and atrial muscles are shown in figures 54 and 55, the latter copied from Streiff. Observe the asymmetry in the intermediate muscle of the two sides, and the greater length of the oral retractor muscle on one side.

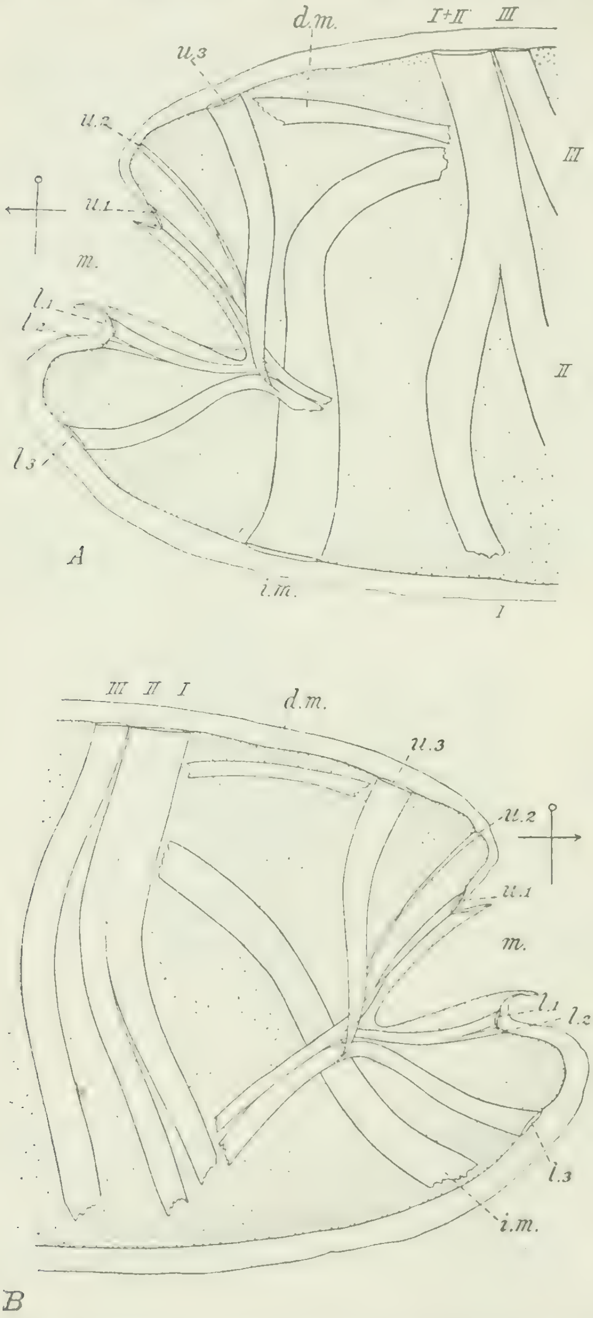

FIG. 51.—APSTEINIA PUNCTATA, AGGREGATED ZOÖID FROM THE LEFT SIDE OF THE STOLON, ORAL MUSCULATURE VIEWED FROM THE INSIDE: *A*, RIGHT SIDE OF THE BODY; *B*, LEFT SIDE OF THE BODY. × 7 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The gut is a compact "nucleus" (fig. 53).

The eyes (figs. 56 and 57) have been described by Metcalf and Johnson (1905). They show definite departure from even the most modified *Cyclosalpa* type, that of *C. virgula*, and conform quite closely to that seen in the true Salpas. That portion of the large dorsal eye which in the Cyclosalpas we called the plug, and which in *Cyclosalpa virgula* is so greatly reduced (*c'''*, figs. 19 and 20, p. 48), is entirely wanting in *Apsteinia punctata.* At the place where it should lie is an intruding branch of the pigment layer (fig. 57, p. 78), which is probably a reminiscence of the former presence of the plug. The other features of the large eye are much as in *Cyclosalpa virgula*, except that it is much shorter, more like the eye of the aggregated *Salpa maxima.*

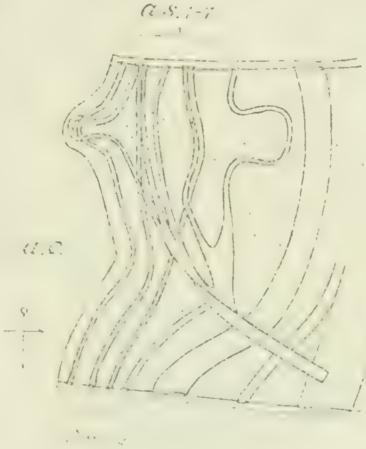

FIG. 55.—APSTEINIA PUNCTATA, AGGREGATED ZOÖID, ATRIAL MUSCULATURE OF THE LEFT SIDE, SEEN FROM WITHIN. FROM STREIFF (1908).

No pairs of minute eyes are found in the ganglion. In the less aberrant *Cyclosalpas* there are two pairs of these very small eyes. In *C. virgula* there are a varying number of still more minute groups of less developed rod-cells. In *Apsteinia punctata*, while the minute eyes are wanting, there is a large group of rod-cells (*ex*) in two layers, one above the other, on the dorsal side of the ganglion, just in front of the origin of the optic nerve. Similar masses of rod-cells, in a corresponding position, are found in the aggregated zoöids of other species of the subgenus *Salpa* (fig. 79, p. 92). In *S. cylindrica* (figs. 87, p. 98, and 89, p. 99) the rod-cells form a single layer; in *S. fusiformis* and *S. maxima* they are irregularly arranged and degenerate. Homologous groups of rod-cells will be described later for *Thalia.*[1]

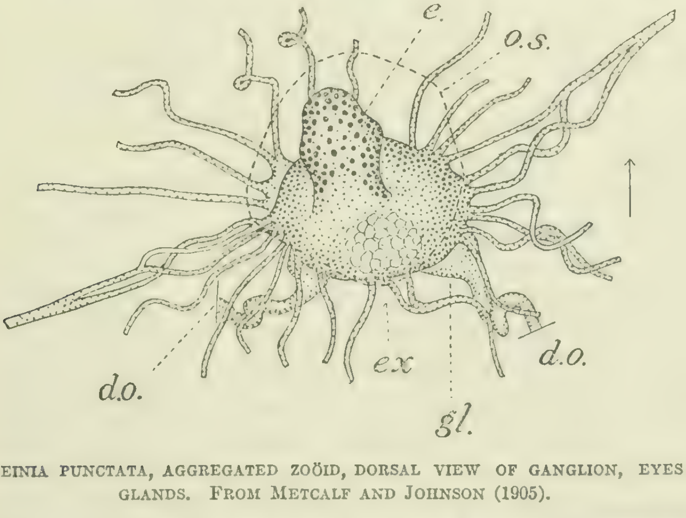

FIG. 56.—APSTEINIA PUNCTATA, AGGREGATED ZOÖID, DORSAL VIEW OF GANGLION, EYES AND NEURAL GLANDS. FROM METCALF AND JOHNSON (1905).

The neural glands show the usual character.

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[1] And for *Apsteinia asymmetrica*, see Appendix, page 183.

APSTEINIA ASYMMETRICA (Fowler, 1896).

Salpa asymmetrica Fowler, 1896.

This species, described by Fowler, has been observed also by Apstein (1901). I have had no specimens.[1] Dober (1912) figures the nervous system, but without detail in the eye, so no use can be made here of his work. Details of the structure of the oral and atrial muscles are not included in these descriptions, nor is the character of the eye sufficiently known for comparisons.

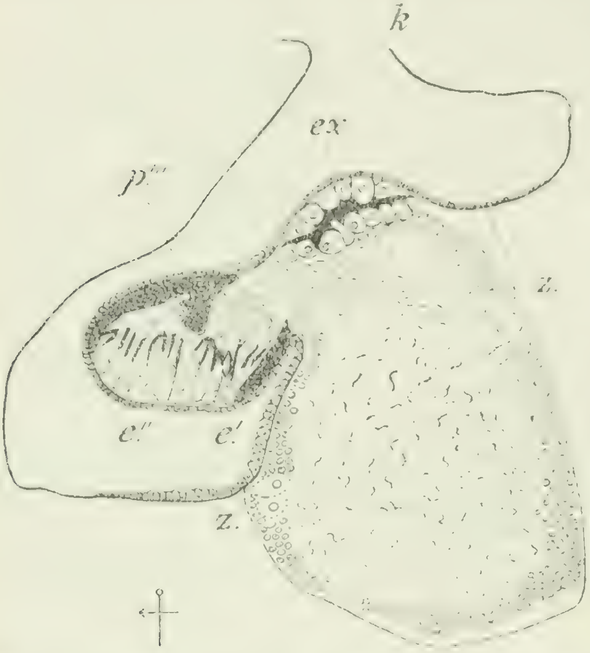

Fig. 57.—Apsteinia punctata, aggregated zoöid, sagittal section of ganglion and eyes. From Metcalf and Johnson (1905).

APSTEINIA ASYMMETRICA, solitary form.

Judging from Apstein's figure (fig. 58), interpreted with the aid of Fowler's side view of the embryo (fig. 59), there are apparently 10 body muscles, though the tenth very possibly belongs to the atrial series. The intermediate muscle and body muscles I and II are in contact dorsally, so also are body muscles III and IV and VIII and IX. The gut is described as a compact "nucleus."

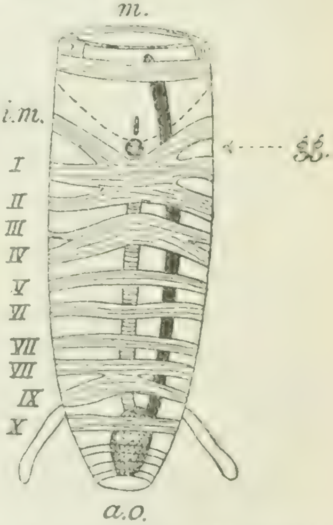

Fig. 58.—Apsteinia asymmetrica, embryo, dorsal view. × 22 diameters. From Apstein (1901).

One interesting feature of the oral musculature is observed in Fowler's figures. There is on each side a strong oral retractor muscle, which posteriorly is bifurcated, as in *Apsteinia punctata,* into dorsal and ventral portions. The ventral division extends back to the fifth body muscle; the dorsal division reaches past all the body muscles to the atrial sphincters. The resemblance to *Apsteinia punctata* is very marked and is a very clear indication of the affinity of the two species. Fowler's description and figures are obscure. He mentions "a right and left longitudinal slip of unequal length in connection with the two circumoral sphincters," evidently meaning that one "slip" is on the right and the other on the left. It seems evident, however, from his figures, and from the relations in other species between oral retractor and oral sphincter muscles, that we have in *Apsteinia asymmetrica* a dorsal and a ventral division of the oral retractor on each side of the body. The junction of the two "slips" and their connection with the oral sphincters, which Fowler figures, is not possible on any other interpretation. I have therefore modified an obscure portion of his "Figure 8" [fig. 59, *B*] to show the dorsal division of the oral retractor passing *over* the gill. Fowler's "Figure 8," though obscure, seems to show the gill above the muscle band.

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[1] Specimens obtained after this paper was in press are described in the Appendix, see page 183.

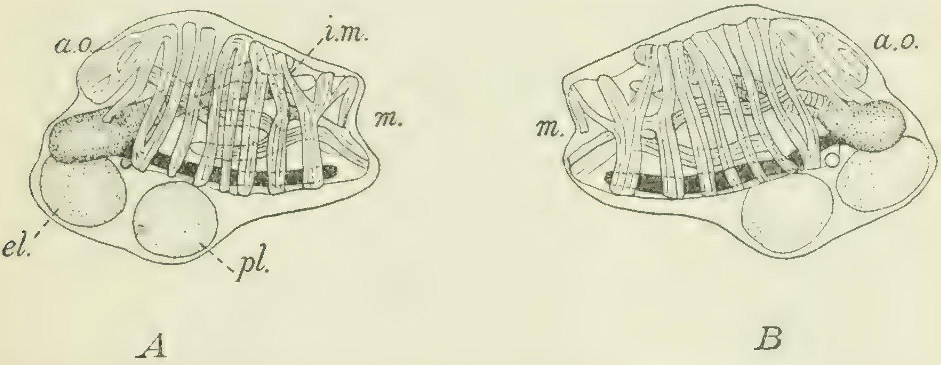

Fig. 59.—Apsteinia asymmetrica embryo: *A*, from the right side; *B*, from the left side × 16 diameters. From Fowler (1896); *B*, slightly modified.

APSTEINIA ASYMMETRICA, aggregated form.

The atrial siphon is asymmetrically placed (figs. 60 and 61). The body muscles also are asymmetrical, their arrangement being rather like that seen in the aggregated *Apsteinia punctata*. There are five upon each side, muscles I, II, and III being asymmetrically in contact dorsally. Muscle V shows the usual anterior and posterior branches. Ventrally the intermediate muscle and all the body muscles are interrupted except the two branches of body muscle V. The ventral ends of the muscles of the right and left sides are very asymmetrical, as shown in the figures. The gut is described as a compact "nucleus." The condition of the eye and neural gland is unknown.

The resemblance between the aggregated forms of this species and *Apsteinia punctata*, in the asymmetry both of the body and of the body muscles, and the compact character of the gut in both solitary and aggregated forms of *Apsteinia asymmetrica*, indicate that this species should be placed among the Apsteinias rather than the

Ritterias. The oral retractor muscle so resembles that of *Apsteinia punctata* as to indicate close relationship between that species and *A. asymmetrica.* The very marked asymmetry of the aggregated zoöids separates this species from the true *Salpae, sensu strictu.*

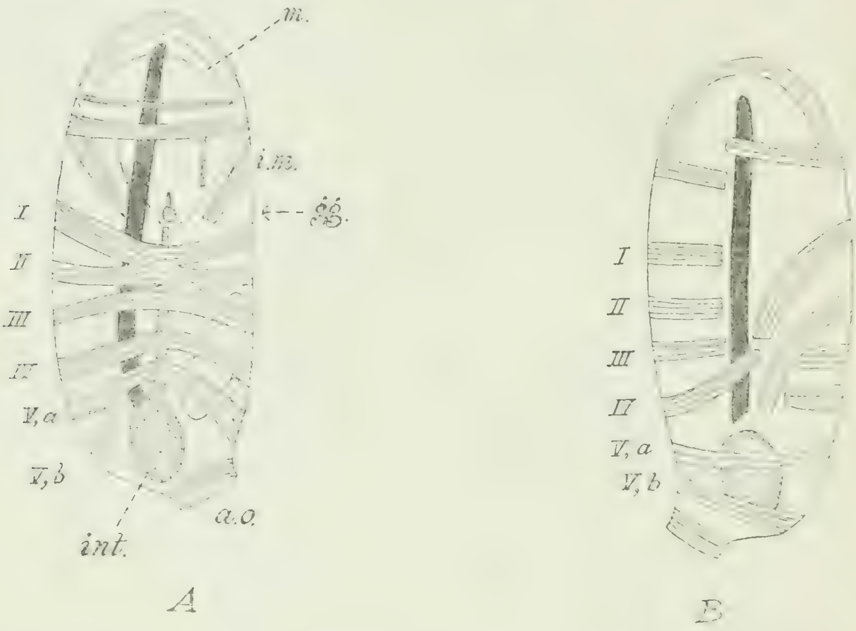
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Fig. 60.—Apsteinia asymmetrica, aggregated form: *A*, dorsal view; *B*, ventral view × 22 diameters. From Apstein (1901).

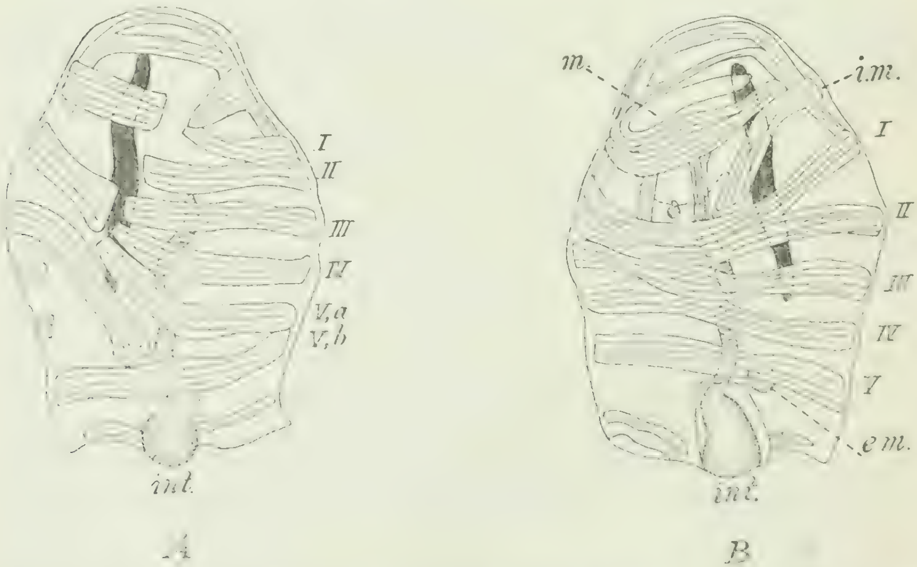
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Fig. 61.—Apsteinia asymmetrica, aggregated zoöid: *A*, ventral view; *B*, dorsal view × 4½ diameters. From Fowler (1896).

APSTEINIA MAGALHANICA (Apstein, 1894, b).

Salpa magalhanica Apstein, 1894, *b*.

This species has been studied by Apstein (1894, *b*) and Streiff (1908). I have had no specimens. Streiff, unfortunately, gives no figures. His descriptions do not fit Apstein's figures, but of course one can not correct Apstein's drawings from a verbal description. I am under the necessity, therefore, of copying Apstein's drawings, in spite of the fact that there is reason to believe them inaccurate in detail.

APSTEINIA MAGALHANICA, solitary form.

The body muscles (fig. 62), seven in number, are broader than those of the solitary *Apsteinia asymmetrica*. Muscles I, II, III, and IV approach one another dorsally and also ventrally, but they are not fused. Muscles V and VI Apstein shows in contact dorsally. Muscles IV and V are in contact laterally. Streiff says that the first cloacal muscle is fused dorsally with the last body muscle. Apstein interprets both as body muscles.

The intermediate muscle and the dorsal horizontal bands in front of body muscle I are shown in figure 62.

From Streiff's description, the oral musculature seems to resemble that of the solitary *Apsteinia punctata*, except there are no elongated posterior branches of the oral retractor. The atrial muscles also seem, from Streiff's description, to show resemblance to those of *Apsteinia punctata*.

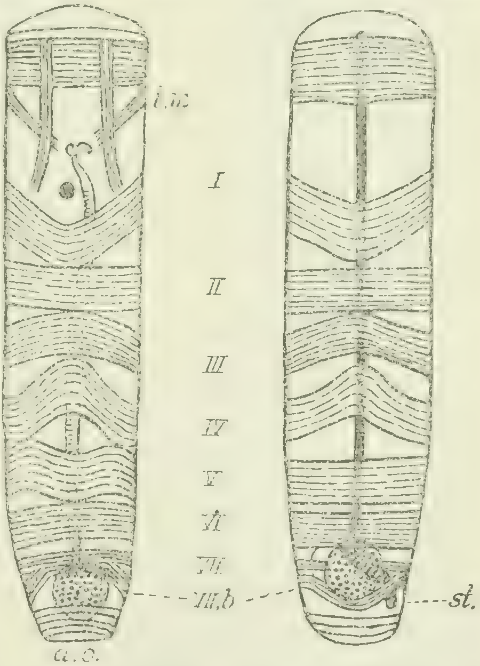

Fig. 62.—Apsteinia magalhanica, solitary form: *A*, dorsal view; *B*, ventral view. × 4 diameters. From Apstein (1906, *b*).

The gut is described as a compact "nucleus."

APSTEINIA MAGALHANICA, aggregated form.

The zoöids are strongly asymmetrical (fig. 63), as noted above, There are five body muscles on each side, whose arrangement is shown in the accompanying figures (from Apstein.) The intermediate muscle is present. It seems to be double. The dorsal horizontal band is also found.

Streiff describes the cloacal musculature as resembling the usual type for tubular cloacal siphons such as are seen in *Apsteinia punctata*. The gut is said by Apstein to be a compact "nucleus." Apstein's description of the eye is too meager for use in our comparisons.

The Apsteinias, as I interpret their relationships, arose from forms which, like the *Cyclosalpae asymmetricales*, had aggregated zoöids with great asymmetry. I have so grouped the species in the subgenus as to show decreasing asymmetry. (See chart on p. 158.) In the true Salpas this asymmetry is much more reduced, affecting none of the muscles except the atrial musculature, and observable in the body form chiefly in the asymmetrical position of the atrial siphon and the protuberances from the body.

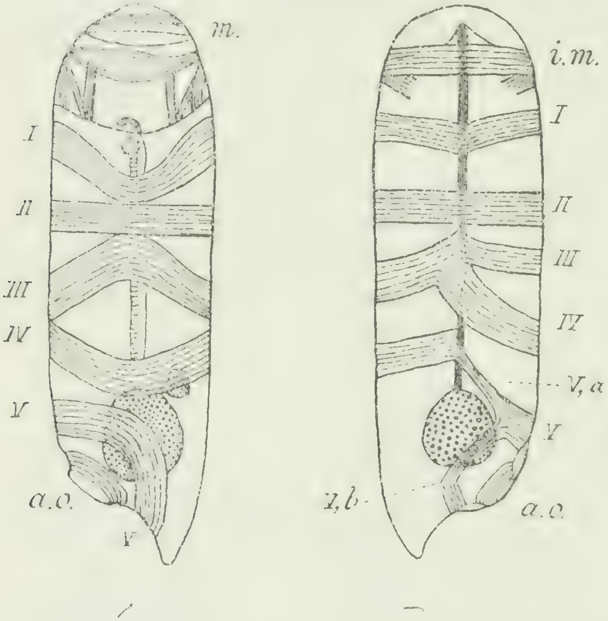

FIG. 63.—APSTEINIA MAGALHANICA, AGGREGATED FORM: *A*, DORSAL VIEW; *B*, VENTRAL VIEW. × 4 DIAMETERS. FROM APSTEIN (1906, *b*).

The Apsteinias are distinguished from the Ritterias (also a subgenus with asymmetrical aggregated zoöids) by the fact that in the former subgenus the gut of both solitary and aggregated forms is a compact "nucleus," while in the Ritterias the gut of the solitary form does not form a nucleus.

Subgenus SALPA (*sensu strictu*) (Forskål, 1775).

In this subgenus I include the species *maxima* and its variety *tuberculata*, *fusiformis* and its form *aspera*, and *cylindrica*. I have very abundant material of all these species. Herdman's description (1888) of the poorly preserved *Salpa mollis* is not sufficient to allow us to discuss its validity as a species, so no further reference will be made to it. The species *fusiformis* may be taken as the type.

The species of this subgenus are very similar to one another in form and musculature. They make a compact and well-demarcated group. The solitary forms of all have nine body muscles. The aggregated zoöids all show more or less asymmetrical anterior and posterior protuberances from the body. In *Salpa maxima* the posterior protuberance is strongly asymmetrical. In *S. fusiformis* both are large and somewhat asymmetrical. In both the type form and the form *aspera* the protuberances are often reduced in size, but are still asymmetrical. In *S. cylindrica* the processes are still more reduced and are nearly symmetrical. The gut in both forms of all species is a compact "nucleus."

SALPA MAXIMA Forskål, 1775.

S. maxima Forskål, 1775.
S. africana Forskål, 1775.
S. birostrata de Blainville, 1827.
(?)*S. forskalii* Lesson, 1832.
S. africana-maxima Krohn, 1846.
S. maxima Apstein 1894, *b*.

This species has been studied by many students, among them Traustedt (1885), Herdman (1888), Brooks (1893), Göppert (1892), Metcalf (1893), and Streiff (1908).

The following specimens are in the collection of the United States National Museum:

Cat. No. 6448, U.S.N.M. (aggregated form), from Naples Zoological Station; 15+ specimens in a chain.

Cat. No. 6459, U.S.N.M. (solitary form), from Naples Zoological Station; one specimen.

Cat. No. 6520, U.S.N.M. (aggregated form), *Albatross* station D. 5458, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 8, 1909; surface; surface temperature, 85° F.; two specimens.

Cat. No. 6525, U.S.N.M. (aggregated form), *Albatross* station D. 5669, Macassar Strait, Philippine Islands; December 29, 1909; surface; surface temperature, 84° F.; two specimens.

Cat. No. 6555, U.S.N.M. (solitary and aggregated forms), Jolo Anchorage, Jolo, Philippine Islands; March 5, 1908; surface; two specimens.

Cat. No. 6557, U.S.N.M. (solitary form), *Albatross* station D. 5539, between Negros and Siquijor, Philippine Islands; August 19, 1909; surface; surface temperature, 83° F.; one specimen.

Cat. No. 6612, U.S.N.M. (solitary form), *Albatross* station D. 5155, Sulu Archipelago, Tawi Tawi group; February 19, 1908; surface; surface temperature, 81° F.; surface density, 1.02437; 13 specimens.

Cat. No. 6614, U.S.N.M. (solitary form), *Albatross* station D. 5166, Sulu Archipelago, Tawi Tawi group; February 24, 1908; surface; surface temperature, 81° F.; surface density, 1.02644; one specimen.

Cat. No. 6616, U.S.N.M. (aggregated form), *Albatross* station D. 5186, between Panay and Negros, Philippine Islands; March 30, 1908; surface; surface temperature, 80° F.; surface density, 1.02530; 13 specimens.

Cat. No. 6627, U.S.N.M. (solitary form), *Albatross* station D. 5162, Sulu Archipelago, Tawi Tawi Island; February 22, 1908; surface; surface temperature, 80° F.; surface density, 1.02147; two specimens.

Cat. No. 6556, U.S.N.M. (aggregated form), Philippines; surface; one specimen.

SALPA MAXIMA, solitary form.

The characteristic shape of the body is well shown in figure 64. The ventral half of the test is comparatively thick and firm. The nine body muscles are limited to the dorsal half of the body. Each is entirely independent.

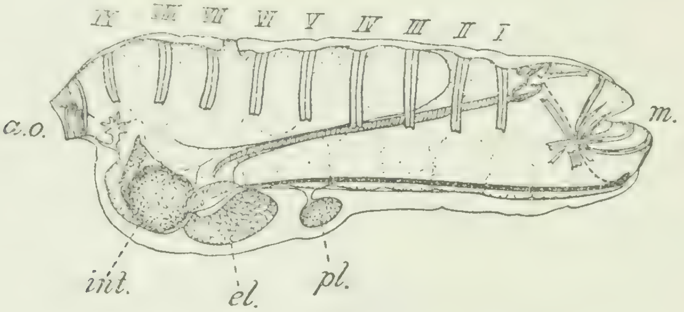

Fig. 64.—Salpa maxima, solitary form, seen from the right side. Natural size. (Drawn by Hoyt S. Hopkins.)

Most of my specimens agree with Streiff's in the character of the oral musculature. (Fig. 65.) This shows the condition in my Mediterranean and Atlantic specimens and in Streiff's material. In another of my specimens, from an unknown locality, the conditions are as in figure 64. In this individual the ventral end of the intermediate muscle is separated from the rest of the muscle. This specimen also has no ventral oral retractor, such as is shown by Streiff, connected anteriorly with dorsal sphincters 2 and 3 and ventral sphincter 2. None of this muscle is present except the postero-ventral end, which is entirely unconnected. It lies behind the ventral moiety of the intermediate muscle. The other oral muscles in this aberrant individual are about as shown by Streiff.

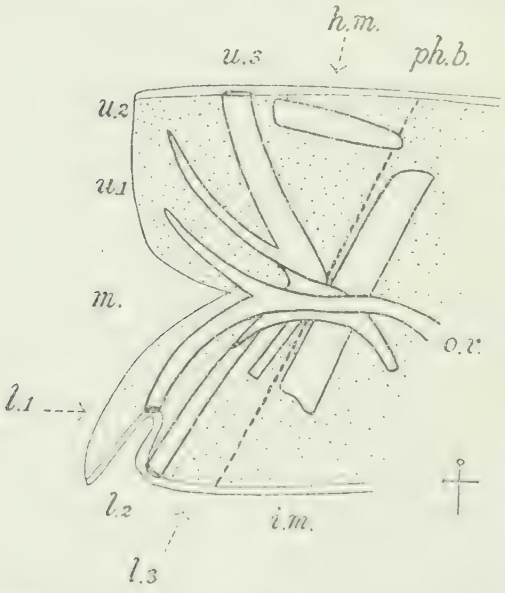

Fig. 65.—Salpa maxima, solitary form, oral muscles seen from the left side. From Streiff (1908).

The atrial muscles are sufficiently shown in figures 64 and 66 without description.

SALPA MAXIMA, aggregated form.

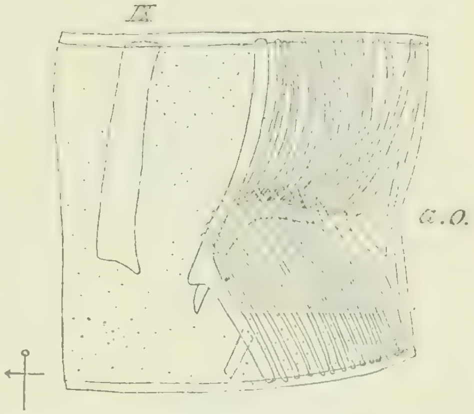

FIG. 66.—SALPA MAXIMA, SOLITARY FORM, ATRIAL MUSCULATURE SEEN FROM THE LEFT SIDE. FROM STREIFF (1908).

The shape of the body and the character of the musculature is shown in figures 67 and 68. There are six body muscles, I and II being fused dorsally, also III and IV. Muscles V and VI approach dorsally and often touch, but do not unite. Muscles II and III touch but are not fused, though often they interlock as shown in figure 67. Muscle VI shows the usual anterior and posterior branches.

Both lips are incurled to act as valves, the lower lip more so than the upper. Streiff's figure of an inside view of the lips (fig. 69) shows well the way in which the muscles aid the lips in their valvular action. The cloacal musculature (fig. 70) is of the same general

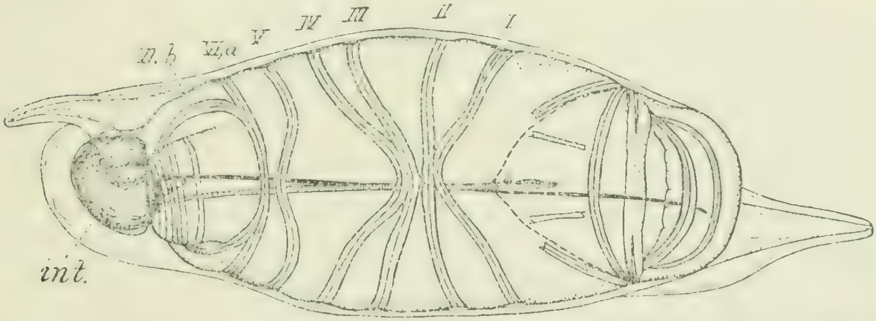

FIG. 67.—SALPA MAXIMA, AGGREGATED ZOÖID. DORSAL VIEW. × 2 DIAMETERS. (DRAWN BY HOYT S HOPKINS.)

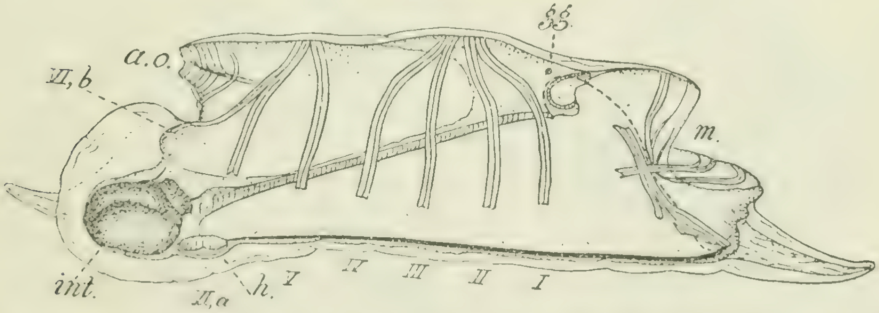

FIG. 68.—SALPA MAXIMA, AGGREGATED ZOÖID, SEEN FROM THE RIGHT SIDE. × 2 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

type we have seen in the aggregated *Cyclosalpa virgula* (pl. 11, fig. 28 and pl. 12, fig 29) and *Apsteinia punctata* (fig. 55, p. 77).

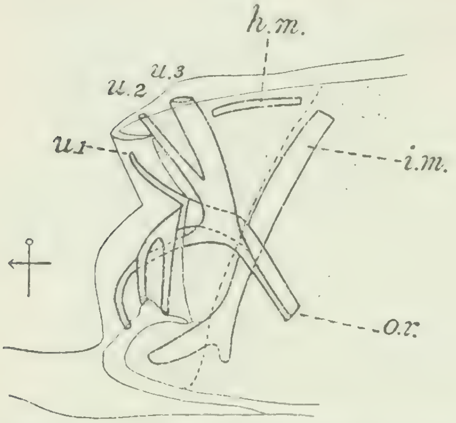

FIG. 69.—SALPA MAXIMA, AGGREGATED ZOÖID, ORAL MUSCLES OF THE RIGHT SIDE, SEEN FROM WITHIN. FROM STRIEFF (1908).

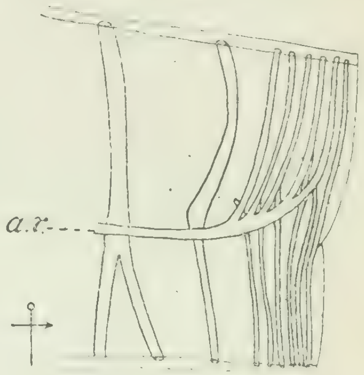

FIG. 70.—SALPA MAXIMA, AGGREGATED ZOÖID, CLOACAL MUSCLES OF THE RIGHT SIDE, VIEWED FROM THE INSIDE. FROM STREIFF (1908).

The eyes show resemblance to those of *Apsteinia punctata* (figs. 56, p. 77, and 57, p. 78) and almost exactly resemble those of *Salpa fusiformis* except that the large dorsal eye is shorter and more compact in *S. maxima*. Figure 79, page 92, a sagittal section of the upper part of the ganglion and the eye of *S. fusiformis* may be used in connection with this description of *S. maxima*. In the larger eye there is a group of rod-cells at the base of the eye, whose thin-walled, innervated ends are dorsal, and at the tip of the eye a group whose thin-walled ends are ventral. Intermediate cells are present between rod-cells and pigment cells in each of the two portions of the eye. The pigment cells are as figured. In the dorsal part of the ganglion there is a good-sized group of short rod-cells not associated with pigment. In *Apsteinia punctata* this group consists, as described, of two horizontal layers of rod-cells with their thick-walled ends contiguous. In *S. maxima* and *S. fusiformis* the rod-cells in the ganglion form an irregular group and the cells are very irregular in form. Degeneration has begun in this ganglionic group of rod-cells. *Apsteinia punctata* has a thickened mass of pigment cells in the position in which, in the Cyclosalpas, the optic plug is found. No such thickening of the pigment layer is seen in *Salpa maxima*. *Salpa maxima* has departed from the archaic condition more than *Apsteinia*, since

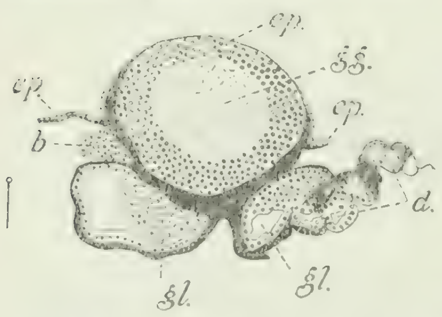

FIG. 71.—SALPA MAXIMA, AGGREGATED ZOÖID, CROSS SECTION OF THE GANGLION AND NEURAL GLANDS × 145 DIAMETERS. FROM METCALF (1893, c).

there is no trace of the optic plug or its pigment, and the rod-cells in the ganglion are degenerate.

The neural glands are more developed than in any other species in the family (fig. 71), the disks and ducts both being larger, and the epithelium within the disks being greatly thickened on the side toward the ganglion. There are two pairs of well-developed outgrowths of cells from the ganglion, toward the disks, one pair (*b*) containing small cells, the other (not figured) containing large cells. The conditions are thus of the usual type, but the structures are unusually well developed.

SALPA MAXIMA, variety TUBERCULATA (new variety), aggregated form.

Only aggregated zoöids of this variety are recognizable in the collections studied. They bear embryos indistinguishable from those of the species type. The collections contain about 50 specimens from station D. 5200, in the Mindanao Sea, Philippine Islands, United States National Museum. Cat. Nos. 6472 (Holotype) and 6454 (Paratypes) U. S. N. M. (aggregated form) *Albatross* station, D. 5200 Pamilacan Island, vicinity western Bohol; April 9, 1908; surface; surface temperature, 79° F.; surface density, 1.02468.

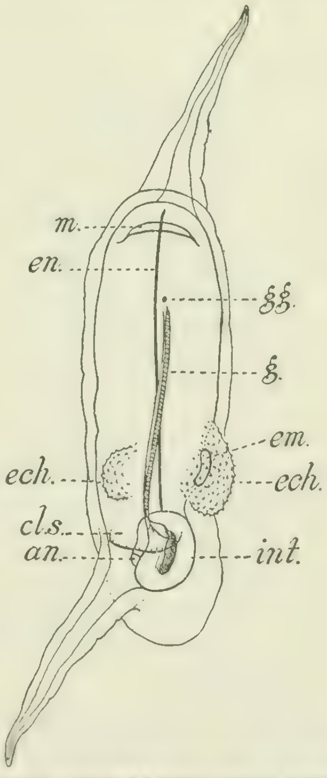

FIG. 72.—SALPA MAXIMA, VARIETY TUBERCULATA, AGGREGATED ZOÖID, DORSAL VIEW; *ech.* ECHINATE AREA OF THE TEST. × 1½ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The musculature of the variety agrees with that of the species type; so also does the structure of all the internal organs.

Two characters distinguish the variety. The anterior and posterior protuberances from the body are as long as in any aggregated zoöids of *Salpa fusiformis*, though they are of the distinctive *S. maxima* character, being more symmetrically placed and more ventral than in *S. fusiformis*. The second distinctive feature is the presence of two areas of tough and thickened test on the dorsal surface of the body on the right and left sides of the base of the atrial siphon. These thickened elevated areas bear numerous short triangular spines. The two spinose areas are of different sizes, the one above the embryo being about twice as large as the other.

The possibility has been considered that this tuberculate variety of *Salpa maxima* may be a hybrid between *S. maxima* proper and

S. fusiformis, form *aspera*, but no indication of this is found. The asperate *S. fusiformis* bears no special spinose thickenings near the base of the atrial siphon. The anterior and posterior protuberances in *S. maxima tuberculata* resemble those of *S. fusiformis aspera* only in their unusual length, not in form or exact position. The test on the ventral surface is thickened as in *S. maxima*, *S. fusiformis aspera* showing no such thickening. The ciliated funnel is curved as in *S. maxima*, not straight as in *S. fusiformis aspera*. The eye is of the short and compact *S. maxima* character, differing from the more elongated *S. fusiformis aspera* eye. The intestinal "nucleus" is a lateral mass in a thick semi-opaque spheroidal protuberance of the test as in *S. maxima* proper, while in *S. fusiformis* and its form *aspera* the intestinal mass protrudes very little and the test surrounding it shows little modification. There seems to be no indication of hybrid character in *S. maxima tuberculata*.

SALPA FUSIFORMIS Cuvier, 1804.

S. maxima, variety, Forskål, 1775.
S. fusiformis Cuvier, 1804.
S. runcinata Chamisso, 1819.
(?) *S. moniliformis* Macculloch, 1819.
(?) *S. dubia* Chamisso, 1819.
S. clostra Milne-Edwards, quoted by Cuvier, 1828.
S. maxima Meyen, 1832.
S. pyramidalis Lesson, 1832.
S. runčinata-fusiformis Krohn, 1846.
S. cymbiola Dall, 1872.
S. fusiformis Apstein, 1893, *b*.

This species, which is one the most abundant of the Salpidae, has been studied by many persons. I have had very abundant material from many localities.

In the collections of United States National Museum the following specimens are listed:

Cat. No. 3067, U.S.N.M. (solitary form), Carnegie Magnetic Expedition, Pacific Ocean between the Hawaiian Islands and California; one specimen.

Cat. No. 6444, U.S.N.M. (embryo), *Albatross* station D. 2029, south of Marthas Vineyard; May 25, 1883; 1,168 fathoms; surface temperature, 53° F.; one specimen.

Cat. No. 6445, U.S.N.M. (aggregated form), Carnegie Magnetic Expedition, Pacific Ocean between Hawaiian Islands and California; four specimens.

Cat. No. 6446, U.S.N.M. (embryo, old), *Albatross* station D. 2583, south of Block Island, September 19, 1885; 131 fathoms; surface temperature, 70° F.; one specimen.

Cat. No. 6522, U.S.N.M. (chain and embryo), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel

Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 2 + specimens.

Cat. No. 6528, U.S.N.M. (solitary form), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay, Philippine Islands; February 4, 1908; surface; surface temperature, 80° F.; one specimen.

Cat. No. 6554, U.S.N.M. (solitary form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; one specimen.

Cat. No. 6580, U.S.N.M. (solitary form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 10 + specimens.

Cat. No. 6581, U.S.N.M. (solitary and aggregated forms), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay; February 4, 1908; surface; surface temperature, 80° F.; 5 + specimens.

Cat. No. 6582, U.S.N.M. (solitary and aggregated forms), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay; February 4, 1908; surface; surface temperature, 80° F.; 6 + specimens.

SALPA FUSIFORMIS, solitary form.

The body muscles (fig. 73) are similar in number and arrangement to those of *S. maxima*, except that they extend more ventrally than in *S. maxima*, and muscles I, II, and III approach and usually touch dorsally, as do also muscles VIII and IX.

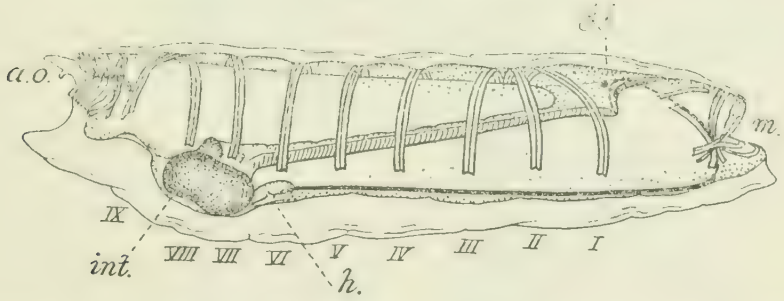

FIG. 73.—SALPA FUSIFORMIS, SOLITARY FORM, VIEWED FROM THE RIGHT SIDE. × 4 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The oral muscles are drawn in figure 74. The atrial muscles are well shown in Streiff's figure (fig. 75). Both sets of muscles are very similar to those of *Salpa maxima*. *S. fusiformis* shows an interruption of the delicate atrial sphincters, near the mid-dorsal line, as does *Apsteinia punctata* (fig. 52, p. 74).

The large dorsal eye (fig. 76) is very similar to that of *Ritteria hexagona* (figs. 39 and 40, p. 66) in histological condition and in form, except that the postero-lateral regions are not enlarged, and the accessory masses of cells (*eq*) lie below the anterior ends of the horseshoe, instead of below its sides.

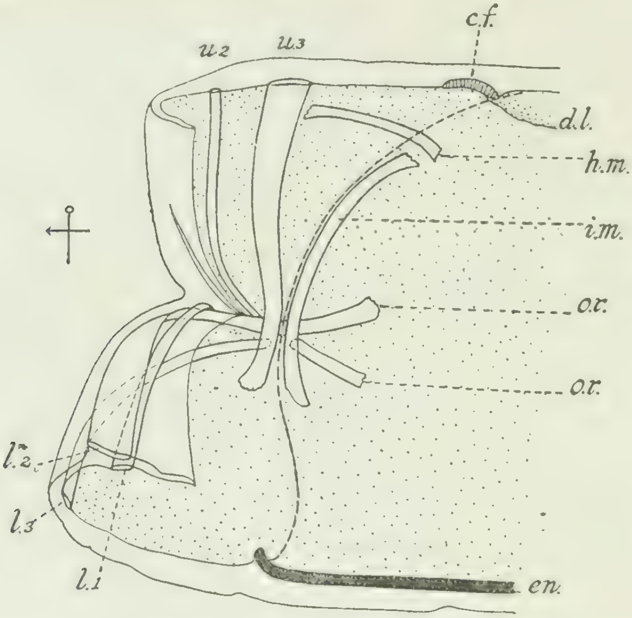

FIG. 74.—SALPA FUSIFORMIS, SOLITARY FORM, ORAL MUSCLES OF THE RIGHT SIDE, SEEN FROM THE INSIDE. × 12 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The ducts of the neural glands are larger than in most species. The disks are of the usual type. There is a distinct outgrowth of large cells from the ganglion, on each side, lying close pressed between the ganglion and the disk of the gland. No small-celled outgrowth is distinguishable.

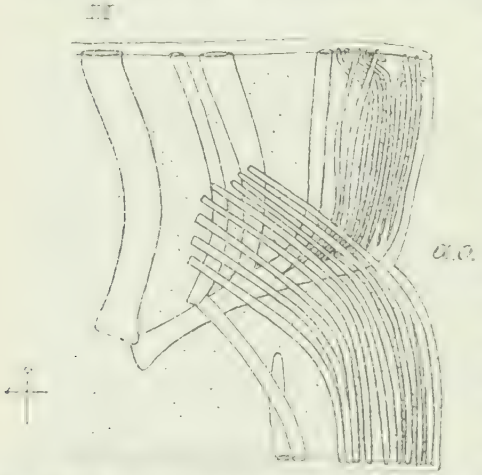

FIG. 75.—SALPA FUSIFORMIS, SOLITARY FORM, ATRIAL MUSCLES VIEWED FROM THE LEFT SIDE. FROM STREIFF (1908).

SALPA FUSIFORMIS, aggregated form.

This closely resembles the aggregated *Salpa maxima*, except that both the anterior and posterior protuberances from the body are generally longer[1] and not so ventral (figs. 77 and 78), while the asymmetry of the posterior end is less noticeable. The body musculature is identical in the two species, except that in *Salpa fusiformis* muscles IV and V always approach each other and often are in contact laterally. There is the closest resemblance also in the oral and atrial musculature.

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[1] Not infrequently these protuberances are short, as shown in figure 81.

The eyes of the aggregated zoöids of *Salpa fusiformis* (fig. 79) and *S. maxima* are more nearly identical in structure than are the eyes of the aggregated forms of any other two species of *Salpa* whose eyes

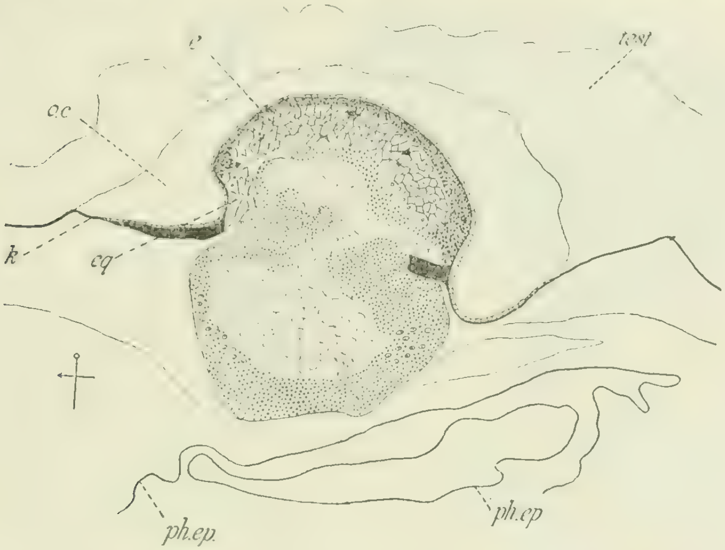

FIG. 76.—SALPA FUSIFORMIS, SOLITARY FORM, PARASIGITTAL SECTION THROUGH THE GANGLION AND ONE LIMB OF THE HORSESHOE-SHAPED EYE. × 197 DIAMETERS. FROM METCALF (1893, c).

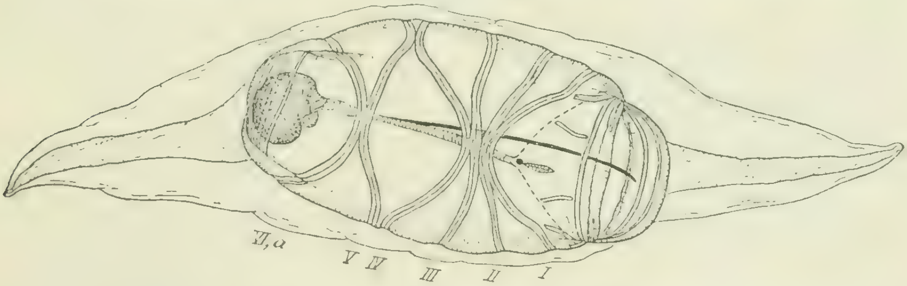

FIG. 77.—SALPA FUSIFORMIS, AGGREGATED ZOÖID, DORSAL VIEW. × 2½ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

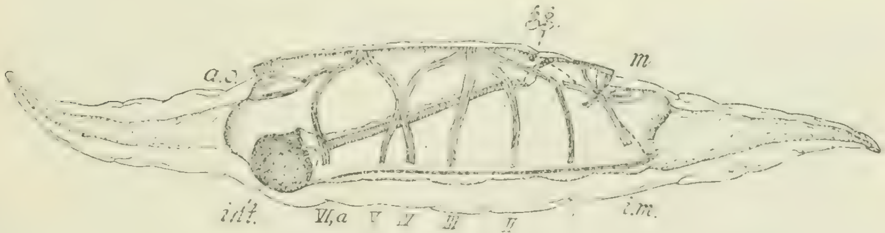

FIG. 78.—SALPA FUSIFORMIS, AGGREGATED ZOÖID, FROM THE RIGHT SIDE. × 2½ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

have been studied. The large antero-dorsal eye is shorter and more compact in *Salpa maxima*, but this is the only observable difference. In the ganglion there is a large mass of irregular degenerate rod-cells, just posterior to the point of origin of the optic nerve. This is comparable to the mass of similar cells in the ganglion of *S. maxima* and to the masses of less modified cells in a similar position in *Apsteinia punctata* (figs. 56, p. 77, and 57, p. 78) and *Salpa cylindrica* (figs. 87, p. 98, and 89, p. 99).

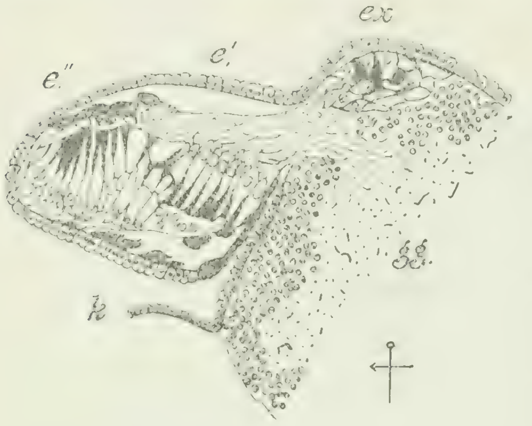

Fig. 79.—Salpa fusiformis, aggregated zoöid, sagittal section of the eyes and part of the ganglion. × 155 diameters. From Metcalf (1903, *c*).

The pigment cells of the large eye in the aggregated form of *Salpa fusiformis* lie outside the limiting membrane of the eye, and so appear to be mesodermal. In all the aggregated Cyclosalpas, as in all solitary forms, the pigment cells are inside the limiting membrane of the eye, which is continuous with that of the ganglion. They appear, therefore, to be ectodermal. There have not been sufficiently careful studies of the development of these cells to determine whether the discrepancy is real or only apparent.

The neural gland is of the usual character. There is a pair of large-celled outgrowths from the ganglion toward the disks of the gland.

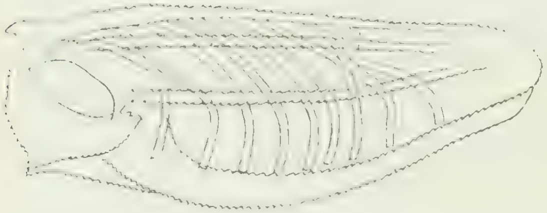

Fig. 80.—Salpa fusiformis, form aspera, solitary individual in postero-dextro-dorsal view. After Ritter (1905), modified.

SALPA FUSIFORMIS, Form ASPERA (Chamisso, 1819).

S. aspera Chamisso, 1819.
(?) *S. vaginata* Chamisso, 1819.
S. echinata Herdman, 1888.
S. fusiformis, var. *echinata* Apstein, 1894, *a*.
S. fusiformis, form *aspera* Ihle, 1911.

The form *aspera* (figs. 80 and 81) is very similar to *Salpa fusiformis* proper. The musculature and all the internal structure, including the character of the eyes, are practically identical in *S. fusiformis* and its form *aspera* in both solitary and aggregated individuals. The aggregated zoöids of both the main species and the spinose form may

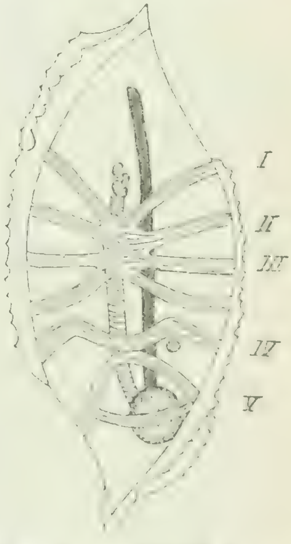

Fig. 81.—Salpa fusiformis, form aspera, aggregated zoöid in dorsal view. × 6 diameters. From Apstein (1906, *b*).

either be elongated, as in figures 77 and 78 of *fusiformis*, or be shorter, as in figure 81 of *aspera*. The only diagnostic feature of *aspera* is the ridged and spinose character of the test in both solitary and aggregated forms, and there is complete intergradation, even in these characters, in my collections, between the smooth form and the most spinose. For well-developed examples of *Salpa fusiformis* form *aspera* see United States National Museum collections, Cat. Nos. 6439 and 6440. For individuals showing a character intermediate between the form *aspera* and the smooth form see United States National Museum collections:

Cat. No. 145, U.S.N.M. (solitary and aggregated forms), *Fish Hawk* station 1027, off Marthas Vineyard; September 14, 1881; 93 fathoms; surface temperature, 65° F.; 10 ± specimens.

Cat. No. 617, U.S.N.M. (aggregated form), *Albatross* station D. 2575, off Cape Cod; September 3, 1885; 1710 fathoms; surface temperature, 71° F.; 10 specimens.

Cat. No. 6441, U.S.N.M. (solitary form), *Albatross* stations D. 5020–5021, off Maryland; May 21, 1883; 179 fathoms; surface temperature, 54° F.; 4 ± specimens.

Cat. No. 6442, U.S.N.M. (aggregated form), *Fish Hawk* station 925, off Marthas Vineyard; July 16, 1881; surface temperature, 71° F.; 6 + specimens.

Cat. No. 6613, U.S.N.M. (solitary form), *Albatross* station D. 5125, Sulu Sea, vicinity of southern Panay, Philippine Islands; February 3, 1908; surface; surface temperature, 80° F.; surface density, 1.02444; 1 + specimen.

Cat. No. 6583, U.S.N.M. (solitary form), *Albatross* station D. 5106, China Sea, off southern Luzon, Philippine Islands; November 7, 1909; surface; surface temperature, 78° F.; surface density, 1.02393; 2 + specimens.

SALPA CYLINDRICA Cuvier, 1804.

Iasis cylindrica SAVIGNY, 1816.
S. coerulescens CHAMISSO, 1819.

This species, while less common than *Salpa fusiformis*, is fairly abundant and has been studied by a good many persons. Streiff, who has done such accurate work on the musculature of other species, has not studied this Salpa.

Specimens of this species in the collections of the United States National Museum are as follows:

Cat. No. 6447, U.S.N.M. (solitary form), *Albatross* station D. 2542, south of Block Island; August 7, 1885; 129 fathoms; surface temperature, 76° F.; 4 specimens.

Cat. No. 2687, U.S.N.M. (aggregated form), off Newport, Rhode Island; U. S. F. C., 1880; 75 + specimens.

Cat. No. 6526, U.S.N.M. (solitary form), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay, Philippine Islands; February 4 1908; surface; surface temperature, 80° F.; 2 specimens.

Cat. No. 6534, U.S.N.M. (solitary and aggregated forms), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 15 + specimens.

Cat. No. 6558, U.S.N.M. (solitary form), *Albatross* station D. 5125, Sulu Sea, vicinity southern Panay, Philippine Islands; February 3, 1908; surface; surface temperature, 80° F.; surface density, 1.02444; 1 specimen.

Cat. No. 6559, U.S.N.M. (solitary form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Island; June 7. 1909; surface; surface temperature, 86° F.; 10 + specimens.

Cat. No. 6560. U.S.N.M. (solitary form), *Albatross* station D. 5456, east Coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 1 specimen.

Cat. No. 6561, U.S.N.M. (solitary form), *Albatross* station D. 5186, between Panay and Negros, Philippine Islands; March 30, 1908; surface; surface temperature, 80° F.; surface density, 1.02530; 2 specimens.

Cat. No. 6576, U.S.N.M. (solitary form), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay, Philippine Islands; February 4 1908; surface; surface temperature, 80° F., 2 + specimens.

Cat. No. 6577, U.S.N.M. (solitary and aggregated form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 10 + specimens.

Cat. No. 6578, U.S.N.M. (aggregated form), Kowloon, China; September 8, 1908; surface; 25 + specimens.

Cat. No. 6579, U.S.N.M. (solitary form), *Albatross* station D. 5616, Molucca Passage, Philippine Islands; November 22, 1909; surface; surface temperature, 84° F.; 1 + specimen.

Cat. No. 6584, U.S.N.M. (solitary form), *Albatross* station D. 5627, between Gillolo and Kayoa Islands, Philippine Islands, November 29, 1909; surface; surface temperature, 83° F.; 4 specimens.

Cat. No. 6588, U.S.N.M. (solitary form), *Albatross* station D. 5102, China Sea off southern Luzon, Philippine Islands; January 6, 1908; surface; surface temperature, 81° F.; surface density, 1.02447; 4 + specimens.

Cat. No. 6589, U.S.N.M. (aggregated form), Batangas Bay, Philippine Islands; July 22, 1908; surface; 25 + specimens.

Cat. No. 6624, U.S.N.M. (aggregated form). *Albatross* station D. 5155; Sulu Archipelago, Tawi Tawi Group; February 19, 1908; surface; surface temperature, 81° F.; 1 specimen.

SALPA CYLINDRICA, solitary form.

In the general shape of the body the solitary form of *Salpa cylindrica* (fig. 82) resembles that of other species of the true Salpas. The nine body muscles are all continuous dorsally across the mid line. Ventrally they all extend farther down than in *Salpa maxima* or *S. fusiformis*, but do not reach the mid-ventral line. Body muscles I to IV are in contact dorsally. As in the other true *Salpae*, the intermediate muscle is associated with the oral muscles rather than the body muscles.

There is a single oral retractor muscle, which gives rise directly to the two sphincters of the lower lip and is in contact with the basal ends of the admarginal sphincter of the dorsal lip. A second, broader sphincter of the upper lip passes inside the oral retractor muscle, just in front of the intermediate muscle. The short dorsal longitudinal muscle of the oral series is not in contact with the oral sphincters or the intermediate muscle, but is independent.

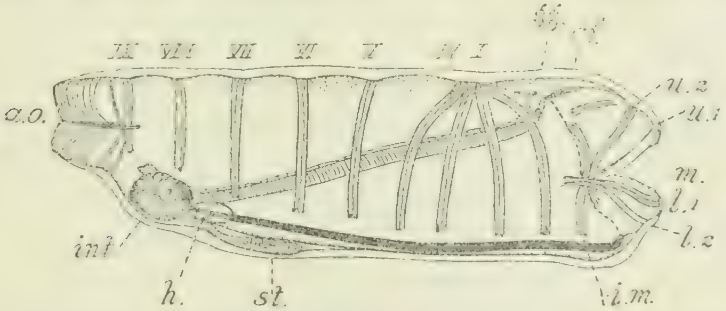

FIG. 82.—SALPA CYLINDRICA, SOLITARY FORM, VIEWED FROM THE RIGHT SIDE. × 6 DIAMETERS. FROM RITTER (1905) WITH MODIFICATIONS.

There is a well-developed atrial retractor muscle on each side, similar to the corresponding muscle of *Salpa maxima*. The arrangement of the atrial sphincters is also somewhat similar in the two species.

The gut is a compact "nucleus," as in the other true Salpas. The stolon is straight, lying below the endostyle. The eye is in the usual horse-shoe form. The neural glands and their ducts are in the usual condition, but there are no outgrowths from the ganglion

SALPA CYLINDRICA, aggregated form.

This form (figs. 83 and 84) has hollow conical anterior and posterior protuberances from the body, slightly asymmetrically arranged. Some specimens show irregular connective tissue fibers in the anterior protuberance, reaching to its tip. At the base of the protuberance these connective tissue fibers lie just in front of and practically continuous with the ventral ends of the intermediate muscles. One is a little doubtful whether these conditions justify comparison functionally with the muscle bands in the anterior protuberance in the solitary *Brooksia rostrata.* Similar fibers are seen in the posterior protuberance of the aggregated *Salpa cylindrica,* and in both the anterior and the posterior protuberances of the aggregated zoöids of *Salpa maxima* and *S. fusiformis,* but in all three species the test is too thick and firm to allow much if any movement.

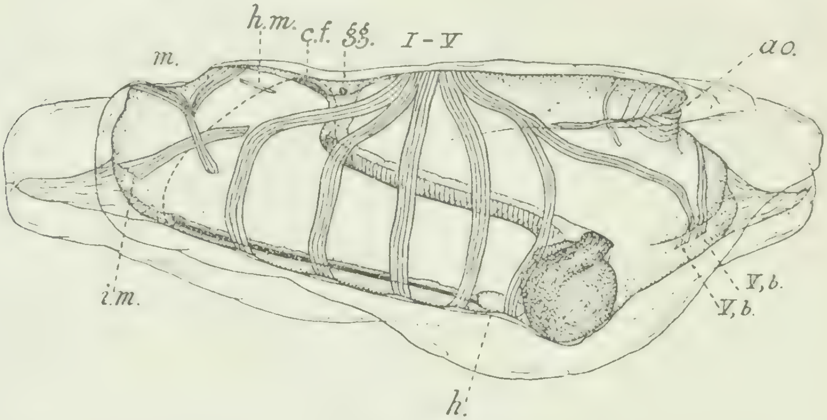

FIG. 83.—SALPA CYLINDRICA, AGGREGATED ZOÖID FROM THE LEFT SIDE OF THE STOLON, VIEWED FROM THE LEFT SIDE. × 7 DIAMETERS. THE SPECIMEN WAS COLLECTED OFF THE COAST OF CHINA. (DRAWN BY HOYT S. HOPKINS.)

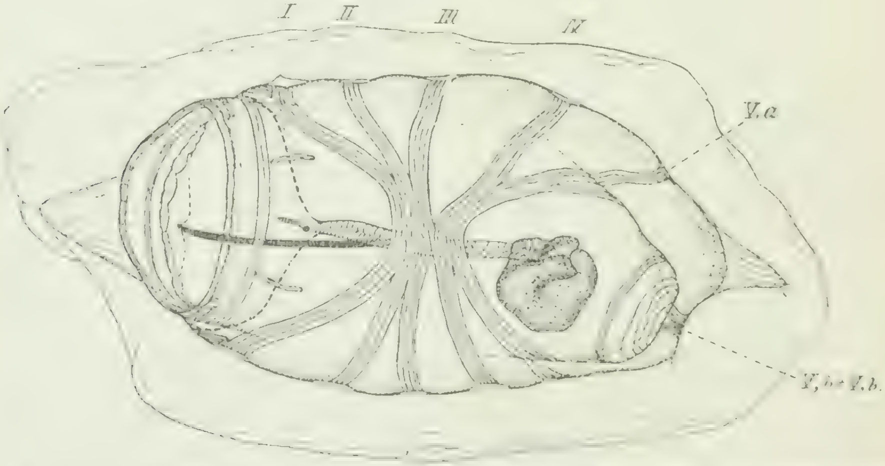

FIG. 84.—SALPA CYLINDRICA, AGGREGATED ZOÖID FROM THE LEFT SIDE OF THE STOLON, DORSAL VIEW. × 7 DIAMETERS. THE SPECIMEN WAS COLLECTED OFF THE COAST OF CHINA. (DRAWN BY HOYT S. HOPKINS.)

The five body muscles are continuous across the dorsal mid line and are arranged in two groups, I, II, and III in contact dorsally, as also are IV and V. Muscles III and IV are in contact in some specimens, while in others they are distinct. Body muscle V is branched in the usual way, its posterior branch, on each side, passing to the base of the atrial siphon. Behind the siphon, at its base, these posterior branches are contiguous or may unite, forming a single band, which runs to one side of the broadly conical mantle tube that enters the asymmetrical posterior protuberance from the body. The united portion of these muscles doubtless corresponds to the visceral muscle of the *Cyclosalpas*.

The intermediate muscle is reduced (fig. 83), lying well down on the side of the body, at the base of the oral siphon. Its anterior end runs to the base of the anterior protuberance of the mantle. Its posterior end approaches, but does not unite with, the first body muscle. It is associated with the oral muscles, rather than the body muscles.

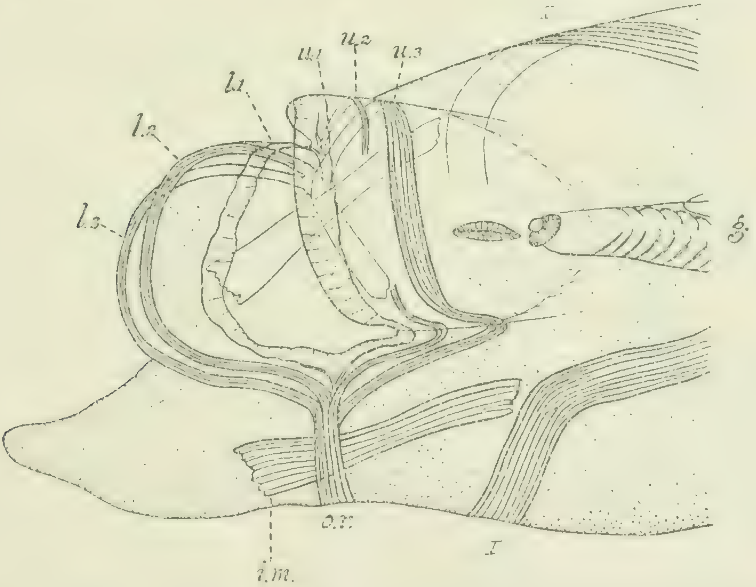

FIG. 85.—SALPA CYLINDRICA, AGGREGATED ZOÖID, ORAL MUSCLES, LAEVO-DORSAL VIEW. THE TEST IS OMITTED.

The oral muscles (fig. 85) consist of a well-developed oral retractor which gives rise antero-dorsally to three sphincter muscles on each lip, the arrangement of these muscles being a complicated one. A few postero-dorsal strands of the retractor are continued into the first and second sphincters of the upper lip and the first sphincter of the lower lip. The second sphincter of the upper lip is short, extending only a little beyond the angle of the mouth. The antero-ventral strands of the oral retractor divide into two sets of fibres, an internal set, which bend sharply back to form the broad third sphincter of the upper lip, and an external set, which immediately divide into two groups to form respectively the second and third sphincters of the lower lip.

The atrial system (fig. 83) shows a well-developed retractor muscle either united, or almost united, at its base, to body muscle V at its point of branching. This retractor muscle is connected distally with six or seven sphincter muscles, the basal one of which is considerably the stronger. The fibers of the sphincter muscles cross over one another where they join the retractor, as shown in the figure.

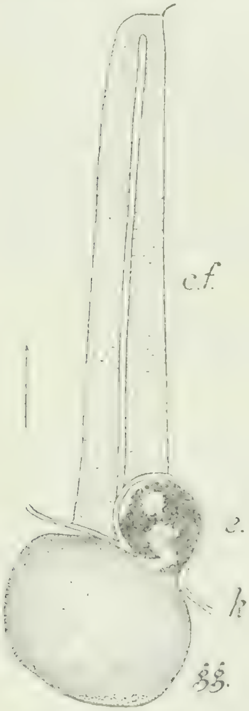

FIG. 86.—SALPA CYLINDRICA, AGGREGATED ZOÖID, DORSAL VIEW OF GANGLION, EYE AND CILIATED FUNNEL. × 130 DIAMETERS. FROM METCALF (1893, c).

The neural gland is reduced in the aggregated *Salpa cylindrica*. On the right side of laeval individuals and on the left side of dextral individuals the only remnant of the gland is a funnel-shaped pit in the wall of the branchial chamber, originally the mouth of the duct. The duct itself, with the disk, has wholly disappeared. On the other side the disk is wanting, but the distal portion of the duct is present, as is also its pharyngeoatrial aperture. There is a pair of small-celled outgrowths from the ganglion at the points where the disks of the neural glands used to lie. (See Metcalf, 1903, *c*.)

The larger, dorsal eye (figs. 86, 87, and 88) is unique among the Salpidae. It has basal and terminal portions of the usual type, though very compactly arranged, as if by a shortening of the antero-posterior axis of the eye. At the point where these two portions join there is a small distinct group of optic cells (*a* in fig. 88, *A* and *B*) on each side, not shown in similar form in any other species studied. The thin-walled ends of these rod-cells is toward the axis of the eye, and their thickened rods are just beneath the ectodermal epithelium of the optic chamber. The homologies of these two groups of rod-cells can be determined only by a study of their origin in the developing zoöids, a study I have not yet undertaken.

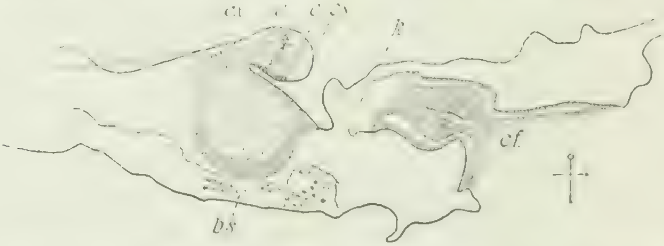

FIG. 87.—SALPA CYLINDRICA, AGGREGATED FORM, SAGITTAL SECTION OF THE GANGLION, EYES, AND THE BASAL PORTION OF THE CILIATED FUNNEL. × 98 DIAMETERS. FROM METCALF (1893, c).

In the ganglion there is one large accessory eye (figs. 87, *ex* and 89) in very much the same position it occupies in *Salpa runcinata* and

Apsteinia punctata. It consists of a single layer of rather short but well-developed rod cells, whose thick-walled ends ("rods") lie external, just beneath the limiting membrane of the ganglion. The thin-walled ends of these rod cells are innervated directly from the large optic nerve which passes between the accessory eye and the large dorsal eye.

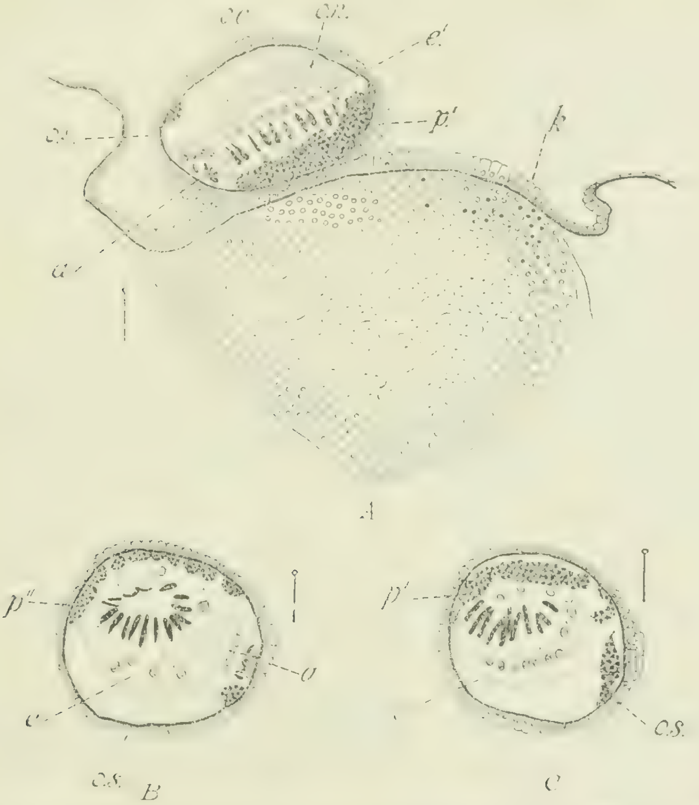

FIG. 88.—SALPA CYLINDRICA, AGGREGATED FORM, TRANSVERSE VERTICAL SECTIONS OF THE GANGLION AND DORSAL EYE: *A*, IS NEAR THE BASE OF THE EYE; *C*, NEAR THE TIP; AND *B*, INTERMEDIATE. × 360 DIAMETERS. FROM METCALF (1893, *c*).

Close relationship of *Salpa cylindrica* to the other true Salpae seems to be indicated by the close resemblance of their solitary forms and by the resemblance in form and musculature between their aggregated zoöids. The unique character of the eyes of the aggregated zoöids is remarkable. They foreshadow, in some regards, the eyes of *Thalia*, as will be seen later.

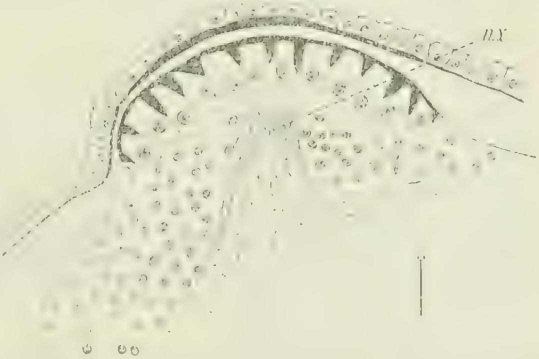

FIG. 89.—SALPA CYLINDRICA, AGGREGATED FORM, VERTICAL SECTION THROUGH THE ACCESSORY EYE AND PART OF THE GANGLION. FROM METCALF (1893, *c*).

Subgenus Jasis (Herdman, 1891).

IASIS ZONARIA (Pallas, 1774).

Holothurium zonarium Pallas, 1774.
Salpa polycratica Forskål, 1775.
Holothuria zonaria Linnaeus, 1788–1791.
Salpa zonaria Bruguiere, 1789.
S. cordiformis Quoy and Gaimard, 1827.
S. microstoma Quoy and Gaimard, 1827.
S. unicuspidata Quoy and Gaimard, reference by de Blainville, 1827.
S. tricuspida Lesson, 1832.
S. cordiformis-zonaria Krohn, 1846.
S. nitida Herdman, 1888.
Iasis cordiformis-zonaria Herdman, 1891.
Salpa zonaria Apstein, 1894, *b*.

In this subgenus I include only one species, *zonaria*. Its relationships are doubtful. They will be discussed later. I have had abundant material of both solitary and aggregated forms.

Cat. No. 6431, U.S.N.M. (solitary form with chain), Fort Mansfield, Rhode Island; 2 specimens.

Cat. No. 6434, U.S.N.M. (aggregated form), Grampus, Gulf Stream (Prof. W. Libby); 12 specimens in a chain.

Cat. No. 6466, U.S.N.M. (aggregated form with embryos), from Naples Zoological Station; 1 specimen.

Cat. No. 6536, U.S.N.M. (aggregated form), *Albatross* station D. 5237, Pacific Ocean, east coast Mindanao, Philippine Islands; May 12, 1908; surface; surface temperature, 85° F.; surface density, 1.02477; 3 specimens.

Cat. No. 6537, U.S.N.M. (aggregated form), *Albatross* station D. 5402, between Leyte and Cebu, Philippine Islands; March 16, 1909; surface; surface temperature, 81° F.; 1 specimen.

Cat. No. 6538, U.S.N.M. (aggregated form), *Albatross* station D. 5196. Off northern Cebu Island, Philippine Islands; April 3, 1908; surface; surface temperature, 82°; surface density, 1.02518; 1 specimen.

Cat. No. 6540, U.S.N.M. (aggregated form), *Albatross* station D. 5186. Between Panay and Negros, Philippine Islands; March 30, 1908; surface; surface temperature, 80° F.; surface density, 1.02530; 2 specimens.

Cat. No. 6541, U.S.N.M. (aggregated form), *Albatross* station D. 5456. East coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 10+ specimens.

Cat. No. 6542, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5669. Macassar Strait, Philippine Islands; December 29, 1909; surface; surface temperature, 84° F.; 5+ specimens.

Cat. No. 6543, U.S.N.M. (aggregated form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 1 specimen.

Cat. No. 6544, U.S.N.M. (aggregated form), *Albatross* station D. 5175, Sulu Sea, southeast of Cagayanes Islands, Philippine Islands; March 8, 1908; surface; surface temperature, 82° F.; 10 + specimens.

Cat. No. 6545, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5186, between Panay and Negros, Philippine Islands; March 30, 1908; surface; surface temperature, 80° F.; surface density, 1.02530; 3 specimens.

Cat. No. 6546, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5500, northern Mindanao and vicinity, Philippine Islands; August 4, 1909; surface; surface temperature, 84° F.; 6 specimens.

Cat. No. 6547, U.S.N.M. (solitary and chain forms); *Albatross* station D. 5672, Macassar Strait, Philippine Islands; December 30, 1909; surface; surface temperature, 83° F.; 15 + specimens.

Cat. No. 6548, U.S.N.M., *Albatross* station D. 5633, south of Patiente Strait, Philippine Islands; December 2, 1909; surface; surface temperature, 84° F.; 10 + specimens.

Cat. No. 6549, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5500, northern Mindanao and vicinity, Philippine Islands; August 4, 1909; surface; surface temperature, 84° F.; 20 + specimens.

Cat. No. 6550, U.S.N.M. (aggregated form), *Albatross* station D. 5530, between Siquijor and Bohol Islands, Philippine Islands; August 11, 1909; surface; surface temperature, 84° F.; 4 specimens.

Cat. No. 6587, U.S.N.M. (aggregated form), *Albatross* station D. 5601, Gulf of Tomini, Celebes; November 13, 1909; surface; surface temperature, 83° F.; 2 specimens.

Cat. No. 6629, U.S.N.M. (aggregated form), *Albatross* station D. 5672, Macassar Strait, Philippine Islands; December 30, 1909; surface; surface temperature, 83° F.; 25 + specimens.

IASIS ZONARIA, solitary form.

There are apparently five broad body muscles (fig. 90) interrupted both dorsally and ventrally. The fifth extends only a short way down on the sides of the body. Possibly this should be accounted a basal atrial sphincter. What seems to be the intermediate muscle (*i. m.*) is of much the same appearance as the body muscles and evidently functions with them.

The oral musculature is unique among the Salpidae. Streiff (1908) describes it without figures, indicating that his figure of the oral muscles in the aggregated form shows also the condition in the solitary form. I find the oral musculature in the two forms very different. All of my many specimens of the solitary *Iasis zonaria* agree and none correspond to Streiff's description in the character of the oral musculature. Streiff's work on other species is so very accurate that one can not think his observations so erroneous upon this form. His account, as it stands, does not agree with conditions in my specimens, but his accuracy as an observer must not be impugned. There is some confusion here. May it be that Streiff had specimens of Herdmann's "*Salpa nitida*," and this form thus proves a distinct subspecies? The body muscles of Streiff's specimens were much broader than those Herdmann figures.

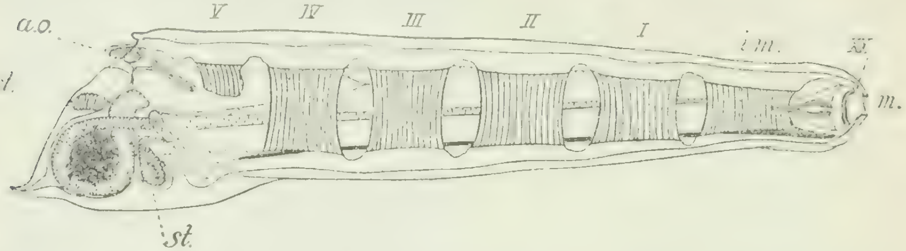

FIG. 90.—IASIS ZONARIA, SOLITARY FORM, SEEN FROM THE RIGHT SIDE. THE MANTLE IS SHRUNKEN AWAY FROM THE TEST ON BOTH DORSAL AND VENTRAL SURFACES. × 1⅗ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

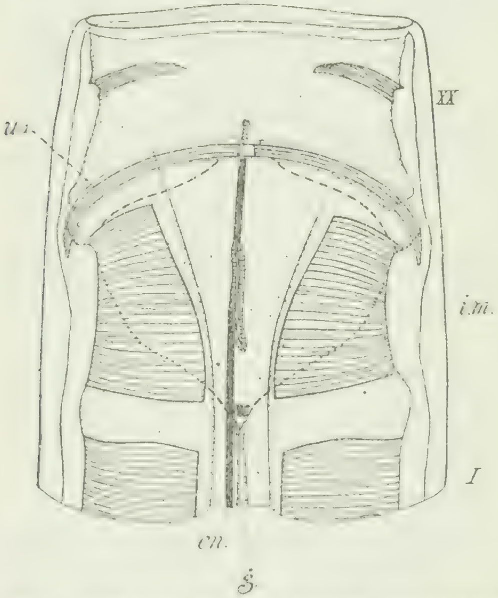

FIG. 91.—IASIS ZONARIA, SOLITARY FORM, DORSAL VIEW OF ANTERIOR END OF BODY. × 3½ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

There is a single strong sphincter muscle in each lip (fig. 91). At the angles of the mouth their ends are united and run back a short way together, forming an oral retractor muscle. These sphincter muscles lie at the edges of the strongly inturned lips (fig. 92). Each is interrupted on the mid line. Further forward on the oral siphon, and separated by a considerable interval from the true sphincters, there is, on each side, a muscle (*ex*) of different histological appearance, opaque and browner in specimens preserved in either alcohol or formalin. These lie at the lateral angles of the flattened oral siphon and extend but a short distance onto the flat dorsal and ventral surfaces of the oral siphon. In a few of my older specimens, neither the largest nor the smallest, the muscle is interrupted at the angle of the siphon, making two half muscles instead of one continuous one. The second sphincter muscle of the lower lip, described by Streiff, and his "*Segelmuskel*" ["A"] are not represented in any of my numerous specimens. In the character of its oral musculature in the solitary form, *Iasis zonaria* is the most aberrant of all the Salpidae, great reduction having occurred, and a new muscle (*xx*) being added. Both lips are strongly and

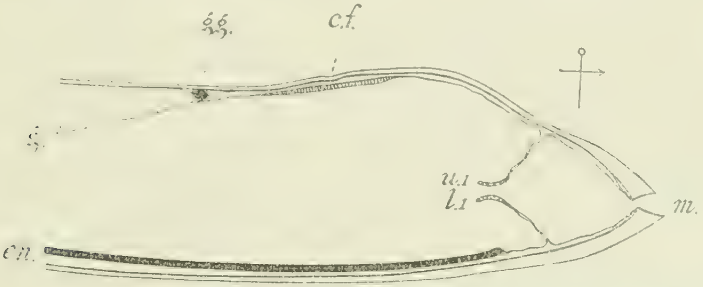

FIG. 92.—IASIS ZONARIA, SOLITARY FORM, A SAGITTAL SECTION OF THE ANTERIOR PART OF THE BODY. × 4 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

equally inturned to serve as valves. The upper lip is somewhat inturned, though less than the lower lip, in some other species (see *Salpa maxima*, aggregated, fig. 69, p. 86, *Thalia democratica*, solitary and aggregated, fig. 104 *B*, p. 111, also figs. 105 and 108).

The musculature of the atrial siphon (fig. 93), in all my specimens agree, except for minor detail, with Streiff's description. There is a

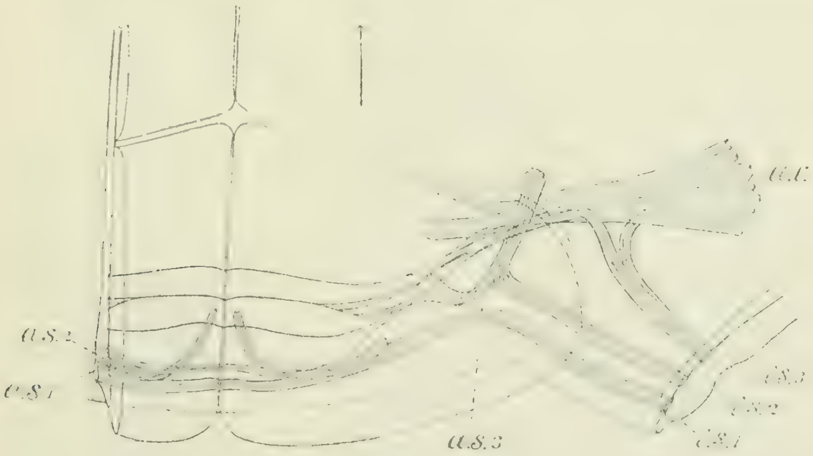

FIG. 93.—IASIS ZONARIA, SOLITARY FORM, DORSAL VIEW OF THE RIGHT SIDE AND A LITTLE OF THE LEFT SIDE OF THE ATRIAL MUSCULATURE, THE ATRIAL SIPHON BEING CUT LENGTHWISE ON THE VENTRAL MID LINE AND THE FLAPS SO FORMED SPREAD OUT LATERALLY. × 13½ DIAMETERS. MODIFIED FROM STREIFF (1908).

strong atrial retractor muscle (*a. r.*) on each side running to near the angle of the atrial opening. The ventral lip of the atrial opening bears three sphincters. The first of these (*v. s. 1*), admarginal, is continuous with the admarginal sphincter (*a. s. 1*) of the dorsal atrial lip. The second ventral sphincter (*v. s. 2*) extends forward, crossing the atrial retractor near its distal end. Near the angle of the atrial opening, this second ventral sphincter is continuous with the third dorsal atrial sphincter (*a. s. 3*) which starts as a single band, but soon breaks up into fine strands that form something of a reticulum. Several strands from this reticulum run forward to join the atrial retractor. These are independent of the main trunk of the third dorsal sphincter, and may represent a fourth dorsal atrial sphincter. The third ventral atrial sphincter (*v. s. 3*) has no connection with muscles of the dorsal atrial lip, but is united by two branches to the middle portion of the atrial retractor. The dorsal lip of the atrial aperture is in two parts. The first, a slightly developed flap, at a lower level, bears dorsal sphincter No. 1. Dorsal sphincter No. 2 is not connected with any other muscle. It lies in the upper division of the upper lip. It is interrupted on the mid line, its two ends being bent forward. The upper portion of the dorsal lip has its test developed to form two triangular stiffened areas, just beneath which lies the reticulum formed by the strands of the third and fourth (?) dorsal atrial sphincters. The vertical section of this region shown in figure 94 should help to make these structures clear.

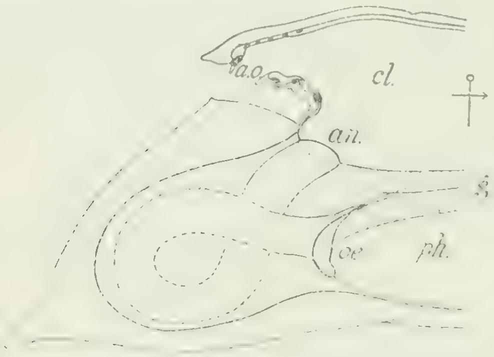

FIG. 94.—IASIS ZONARIA, SOLITARY FORM, SAGITTAL SECTION OF THE ATRIAL APERTURE AND THE ADJACENT TISSUES. × 8 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The gut forms a rather close circular loop (figs. 90 and 94), but is much less compact than in *Apsteinia* and *Salpa* proper. It is much like Apstein's figure of the gut in *Brooksia rostrata* (fig. 23, p. 51).

In the character of its eye and the outgrowths from its ganglion (figs. 95 and 96), the solitary form of *Iasis zonaria* is one of the most aberrant of the solitary Salpidae. Indeed, with the exception of *Ritteria hexagona*, it is the only species in the solitary form of which these structures depart markedly from the usual type. The eye has

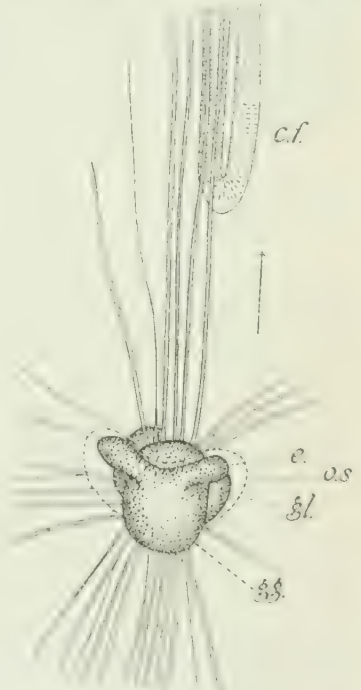

FIG. 95.—IASIS ZONARIA, SOLITARY FORM, DORSAL VIEW OF THE EYE, THE GANGLION, THE NERVES, THE LATERAL OUTGROWTHS FROM THE GANGLION, AND THE POSTERIOR PART OF THE CILIATED FUNNEL. × 57 DIAMETERS. FROM METCALF (1893, c).

its anterior ends elevated above the surface of the ganglion and not in contact with it. The ends are spread apart also, so that the typical horse-shoe shape is distorted to crescent shape.

At the lower edge of the ganglion, on each side, there is a wide rather thin outgrowth (*cy*) of very large irregular cells whose walls are in places thickened, resembling exactly the degenerate rod-cells of the other species of Salpidae. These outgrowths must be interpreted as accessory eyes. In only two other species of Salpidae (*Salpa fusiformis* and *Ritteria hexagona*) does the solitary form have accessory eyes, and these are mere ventral extensions of the mass of rod-cells in the anterior ends (*S. fusiformis*, fig. 76, p. 91), or on the side (*R. hexagona*, figs. 39 and 40, p. 66) of the horseshoe-shaped eye. The structures most similar to these optic lateral outgrowths in the solitary *Iasis zonaria* are the ovoid and somewhat smaller masses of degenerate rod-cells, seen as outgrowths from the sides of the ganglion in the aggregated *Ritteria hexagona* (fig. 45, p. 70 and fig. 47, p. 71). The usually conservative solitary form has, in *Iasis*, departed widely from the general type in the character of the accessory eyes as well as in the form of the dorsal eye, and in the character of the musculature, including the reduction in the number of the body muscles and the peculiar character of the oral and atrial muscles.

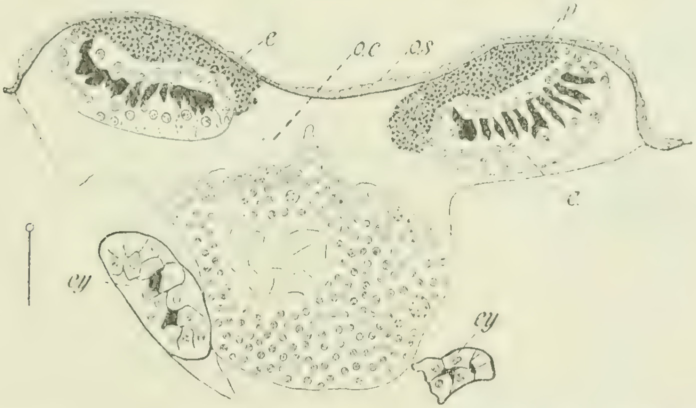

FIG. 96.—IASIS ZONARIA, SOLITARY FORM, CROSS SECTION THROUGH THE GANGLION, THE ANTERIOR LIMB OF THE DORSAL EYE, AND THE LATERAL OUTGROWTHS FROM THE GANGLION. × 200 DIAMETERS. FROM METCALF (1893, *c*).

IASIS ZONARIA, aggregated form.

This zoöid (figs. 97 and 98) is about as asymmetrical as is the aggregated *Salpa cylindrica* (fig. 84, p. 96), the asymmetry being shown in the lateral positions of the posterior protuberance and atrial siphon.

There are five broad body muscles, all but the first continuous across the mid-dorsal line and all widely interrupted ventrally. Body muscle 5 on the right side is divided into an anterior and a posterior branch, the latter, though short, probably the homolog of the posterior branch of the last body muscle in the aggregated zoöids of other species.

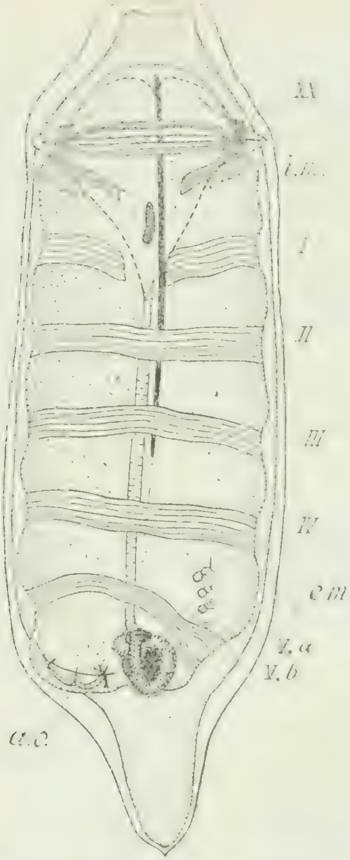

FIG. 97.—IASIS ZONARIA, AGGREGATED ZOÖID, DORSAL VIEW. × 3 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The intermediate muscle is well developed ventrally, extending as near to the mid-ventral line as do the body muscles, but dorsally it passes but a little way beyond the angles of the mouth. Streiff interprets the intermediate muscle as double, an interpretation which seems to be borne out by comparison with some species still to be described.

The oral musculature (fig. 99) shows a short oral retractor, which gives rise, at the angle of the mouth, to a wide admarginal sphincter muscle in each strongly incurved lip. Across the angle of the oral siphon lies a band of dark-colored muscle, comparable to that seen in a similar position at the distal end of the oral siphon in the solitary form of this species. Comparisons, especially with the Cyclosalpas, will show how various are the interrelations of the intermediate muscle and the more basal sphincters of the lips, especially the upper lip. In several species the ventral portion of this sphincter complex is reduced; *Iasis hexagona*, on the other hand, has the dorsal portion reduced.

The condition of the oral musculature, in the very numerous individuals among my material, is considerably different from that

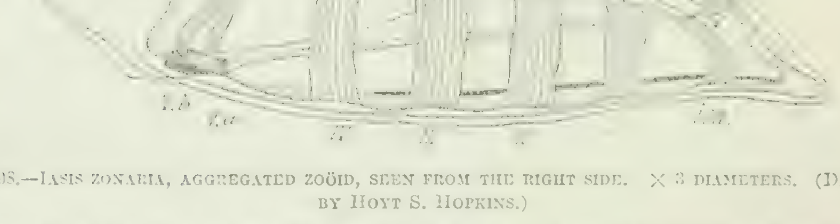

FIG. 98.—IASIS ZONARIA, AGGREGATED ZOÖID, SEEN FROM THE RIGHT SIDE. × 3 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

figured and described by Streiff. I find no delicate second sphincter in the lower lip, such as he describes, and the dark-colored muscle at the angle of the mouth is situated more distally in my specimens.

The atrial siphon and its musculature (fig. 100) in the aggregated *Iasis zonaria* resembles, but is not identical with, that of the solitary form. Dorsally are similar triangular thickenings of the test. One sees a strong atrial retractor (*a. r.*), four ventral atrial sphincters (*v. s. 1–4*), the last three connected with the retractor and the first continuous with the admarginal dorsal sphincter. The second dorsal sphincter is not connected with the second ventral sphincter, differing in this regard from the corresponding muscle in the solitary form.

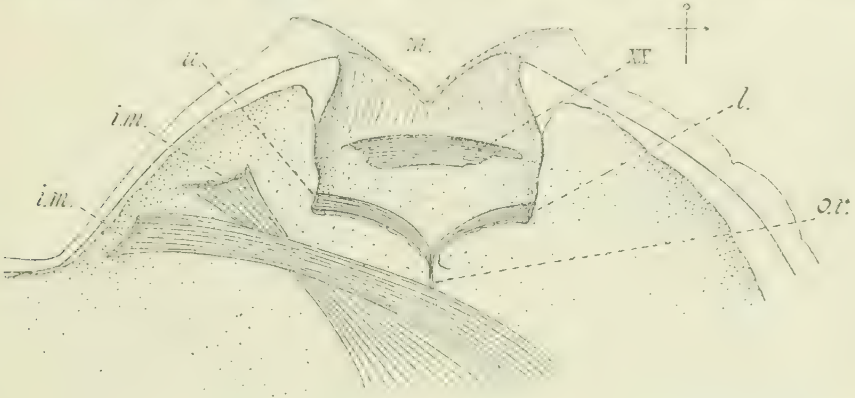

FIG. 99.—IASIS ZONARIA, AGGREGATED FORM, THE LEFT HALF OF THE ORAL SIPHON, SEEN FROM THE INNER SIDE. IT IS SHOWN SLIGHTLY STRETCHED OPEN. × 18 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

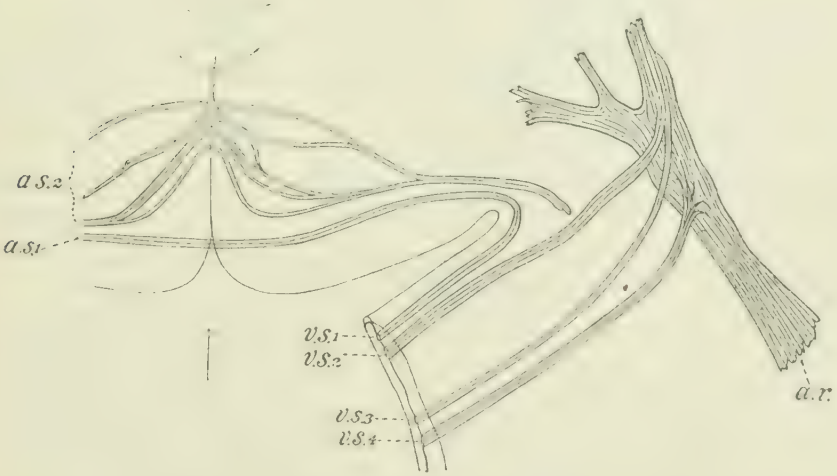

FIG. 100.—IASIS ZONARIA, AGGREGATED FORM, ATRIAL MUSCLES.

Like the third dorsal sphincter in the solitary form, the second dorsal sphincter breaks up distally into a number of fibres, forming a complex whose pattern differs in different individuals, and may even be different on the two sides of the same siphon. The atrial musculature in both solitary and aggregated forms of *Iasis* is very different from that of most other Salpidae, *Thalia democratica* showing the most similar condition.

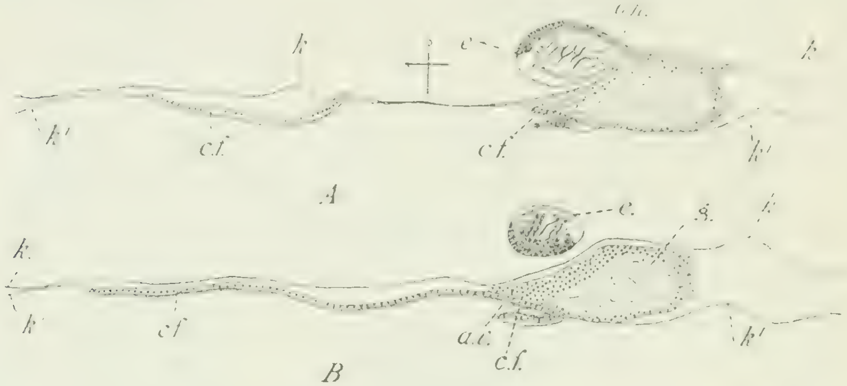

FIG. 101.—IASIS ZONARIA, AGGREGATED ZOÖID, LONGITUDINAL VERTICAL SECTIONS OF THE GANGLION, EYE, AND CILIATED FUNNEL. × 97 DIAMETERS. FROM METCALF (1893, *c*).

The gut (fig. 97) is a compact "nucleus," in which, however, the course of the intestine is readily seen without dissection.

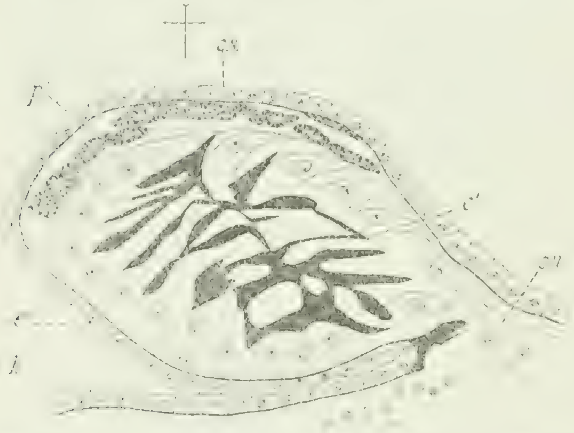

FIG. 102.—IASIS ZONARIA, AGGREGATED FORM, SAGITTAL SECTION OF THE EYE. × 476 DIAMETERS. FROM METCALF (1893, *c*).

The large dorsal eye (figs. 101 and 102) is very compact, the typically distal portion being drawn back beneath the true basal portion, making the whole eye nearly spherical. The thick-walled ends of the rod-cells are somewhat irregular, but the cells can hardly be called degenerate.

There are no accessory eyes in the ganglion of this species, but on each side of the ganglion there is a huge outgrowth (fig. 103 *ey*) composed of irregular cells with unevenly thickened walls, like degenerate rod-cells, as for instance, in the accessory eye of the aggregated *Salpa fusiformis* (fig. 79, p. 92). These outgrowths resemble those of the solitary *Iasis*. They are sessile upon the ganglion. They lie above the lateral pouches of the neural gland, in a position corresponding to that of the large-celled outgrowths from the ganglion in other species, with which they are probably homologous.

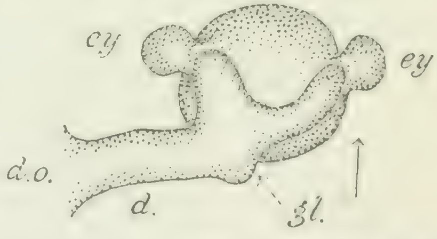

FIG. 103.—IASIS ZONARIA, AGGREGATED FORM, SCHEMATIC VENTRAL VIEW OF THE GANGLION, THE LATERAL OUTGROWTHS FROM THE GANGLION AND THE NEURAL GLAND. × 40 DIAMETERS. A RECONSTRUCTION FROM SECTIONS.

The neural gland (fig. 103) consists of a postero-median chamber, which pushes forward on both sides, beneath the ganglion, to form pouches in the usual positions of the hollow disks. There is but one lateral duct leading from the neural gland to the pharyngeo-atrial chamber. This is very wide.

RELATIONSHIPS OF THE SUB-GENUS IASIS.

Iasis is very distinct from all of the other subgenera. Like most of the species still to be discussed, it has a reduced number of body muscles. It has also a reduced oral musculature, as have also *Thetys*, *Pegea*, *Thalia*, and *Traustedtia*. Its atrial musculature is most like that of *Thalia*. The form of the body in the aggregated zoöids is considerably like that in the aggregated forms of the true *Salpae*. The gut resembles that of *Ritteria* in being a loop in the solitary form and a fairly compact "nucleus" in the aggregated zoöids. The eye of the solitary form is essentially of the ordinary horseshoe type, though distorted in form. In the aggregated zoöids the larger eye, though very compact, shows the usual proximal and distal portions, as seen in the other species of the family thus far discussed. Its neural gland is peculiar. There are usually five embryos present in the aggregated zoöids, showing different stages of development. It is difficult to draw confident conclusions as to the relationships of *Iasis*. I place it as an aberrant form, somewhat intermediate between *Ritteria* and the most divergent forms, *Thetys*, *Thalia*, *Pegea*, and *Traustedtia*.

Subgenus THALIA (Blumenback (?), 1810).

This subgenus includes the species *democratica* and *longicauda* (*flagellifera* of most authors). The former is the most widely distributed and most abundant of all the species of Salpidae. The latter is a rare species which has never been adequately studied. The species *democratica* may be taken as the type since it was the first described and is by far the best known.

THALIA DEMOCRATICA (Forskål, 1775).

Salpa democratica FORSKÅL, 1775.
S. mucronata FORSKÅL, 1775.
(?) *Thalia lingulata* BLUMENBLACH, 1810.
Salpa spinosa OTTO, 1823.
S. pyramidalis QUOY and GAIMARD, 1826–1834.
Biphora mucronata COSTA.
B. democratica COSTA.
Dubreuillia cirrhosa LESSON, 1830.
Salpa democratica-mucronata KROHN, 1846.
S. cabotti DESOR, 1851.
Thalia democratica-mucronata HERDMAN, 1891.
Salpa mucronata APSTEIN, 1894,*b*.
S. democratica HEIDER, 1895.

Specimens of this species are found in the collections of the United States National Museum as follows:

Cat. No. 2809, U.S.N.M. (solitary form and aggregated forms), off Gay Head, Massachusetts; U. S. F. C., September 3, 1884; 100+ specimens.

Cat. No. 6429, U.S.N.M. (solitary form), off Castle Hill, Rhode Island, U. S. F. C. 1880; 20± specimens.

Cat. No. 132, U.S.N.M. (solitary and aggregated forms), *Fish Hawk*, off Newport, Rhode Island, 1880; 20+ specimens.

Cat. No. 6517, U.S.N.M. (solitary and chain forms), Nogas Point, Panay, Philippine Islands; surface; 100+ specimens.

Cat. No. 6521, U.S.N.M. (solitary form), *Albatross* station D 5196, off northern Cebu Island, Philippine Islands: April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; 10+ specimens.

Cat. No. 6524, U.S.N.M. (solitary and aggregated forms), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands, June 7, 1909; surface; surface temperature, 86° F.; 25+ specimens.

Cat. No. 6530, U.S.N.M. (aggregated form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands, June 7, 1909; surface; surface temperature, 86° F.; 10+ specimens.

Cat. No. 6532, U.S.N.M. (solitary form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands, June 7, 1909; surface; surface temperature, 86° F.; 25+ specimens.

Cat. No. 6551, U.S.N.M. (solitary form), *Albatross* station D. 5166, Sulu Archipelago, Tawi Tawi Group, Philippine Islands, February 24, 1908; surface; surface temperature, 81° F.; surface density, 1.02644; 1 specimen.

Cat. No. 6571, U.S.N.M. (solitary and aggregated forms), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay, Philippine Islands, February 4, 1908; surface; surface temperature, 80° F.; 100+ specimens.

Cat. No. 6575, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5588, Sibuko Bay, Borneo, and vicinity, September 28, 1909; surface; surface temperature, 82° F.; 5+ specimens.

Cat. No. 6615, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5196, off Northern Cebu Island, Philippine Islands, April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518 100+specimens.

Cat. No. 6620, U.S.N.M. (solitary and chain forms), *Albatross* station D. 5128, Sulu Sea, vicinity southern Panay, Philippine Islands, February 4, 1908; surface; surface temperature, 80° F.; 1 specimen.

THALIA DEMOCRATICA, solitary form.

There are five body muscles (fig. 104), usually in two groups, I+II+III, and IV+V. In some individuals muscles IV and V do not touch on the dorsal mid line. All are continuous across the dorsal and ventral mid lines. The intermediate muscle is continuous ventrally, but interrupted dorsally.

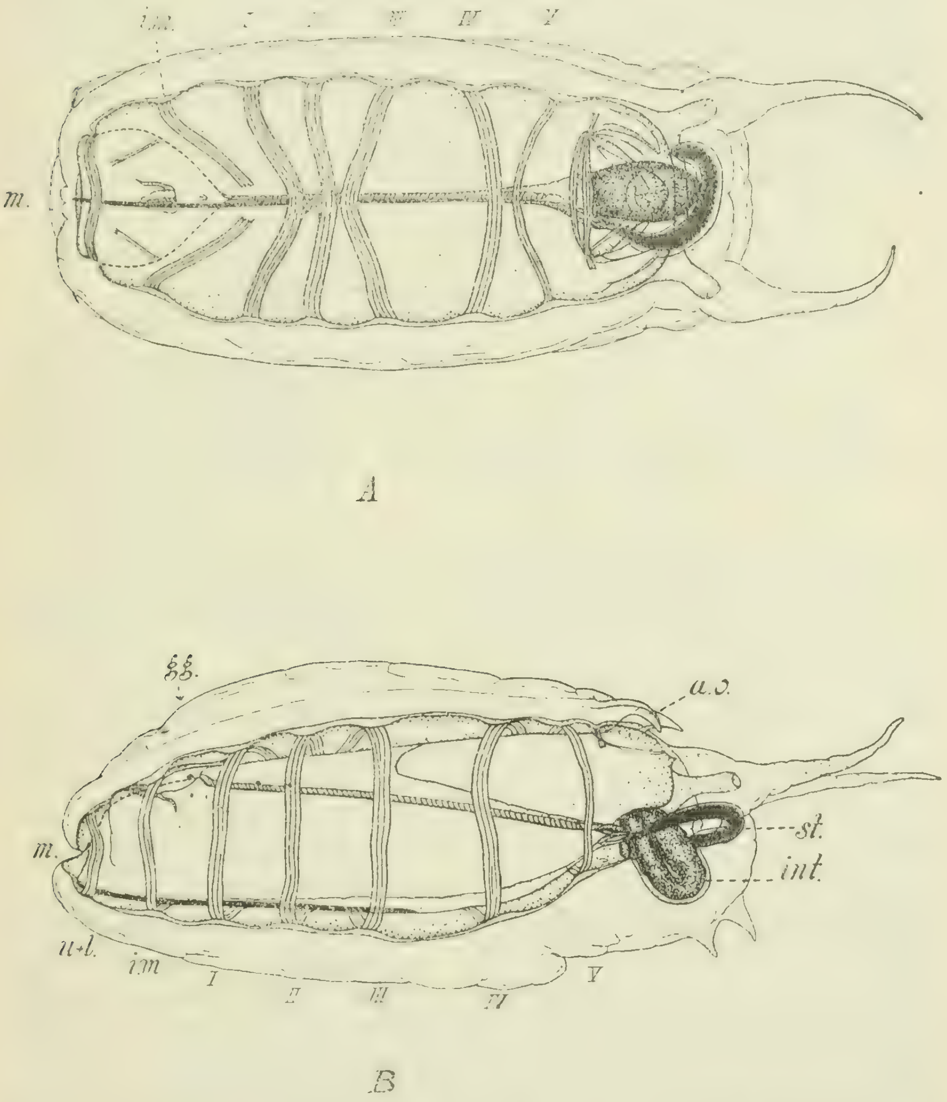

FIG. 104.—THALIA DEMOCRATICA, SOLITARY FORM: *A*, DORSAL VIEW; *B*, SEEN FROM THE LEFT SIDE. × 7½ DIAMETERS. FROM SPECIMENS COLLECTED OFF NEWPORT, RHODE ISLAND. (DRAWN BY HOYT S. HOPKINS.)

The oral musculature is well shown by Streiff (1908), whose figure I copy (fig. 105). The well-developed retractor connects in front with three sphincters of the strongly incurved lower lip and one incomplete admarginal sphincter in the less incurved upper lip. A second strong basal sphincter lies in the upper lip. This divides ventrally into two branches, an anterior, smaller, which gives rise to a fourth sphincter of the lower lip, and a broad posterior branch which Streiff regards as one of two divisions of the intermediate muscle (his "Bogenmuskel") but it seems rather to be comparable to such a ventral extension of the posterior dorsal lip sphincter as we see in *Cyclosalpa*. (See figures of both solitary and aggregated forms of *Cyclosalpa* on plates 1 to 13.) The dorsal horizontal bands are present in the usual position (fig. 104).

The atrial musculature (fig. 106) is a good deal like that of *Iasis zonaria*. Both species have a peculiar triangular area of modified test, in a valve-like position on the dorsal side of the atrial siphon. There is a well developed atrial retractor muscle, which is connected at the angles of the atrial aperture with the broad third sphincter of the upper atrial lip and with a ventral branch which soon divides to form the first and third sphincters of the lower atrial lip. There is a strong continuous band of muscle which forms the broad (fourth) sphincter of the dorsal lip and the second sphincter of the ventral lip. The first and second sphincters of the upper lip are more delicate. They are united at their base, and distally make something of a network, seeming to correspond to the second sphincter of the upper atrial lip of *Iasis zonaria*. The first, admarginal, sphincter, which in *Iasis* is continuous through both atrial lips, is wanting in *Thalia*.

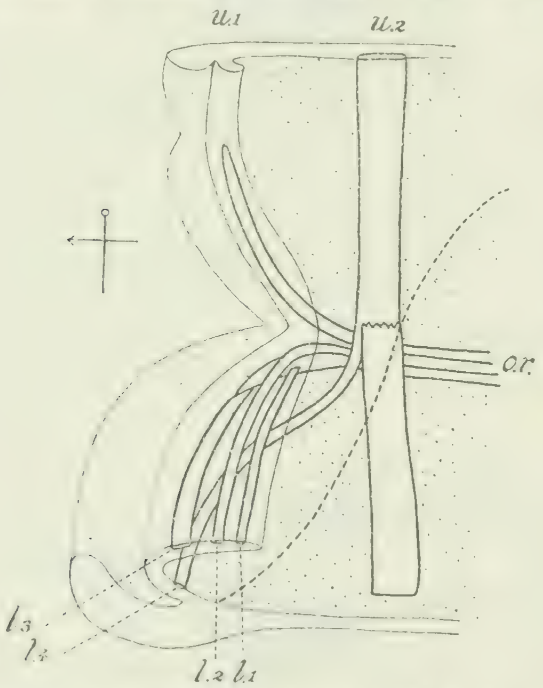

FIG. 105.—THALIA DEMOCRATICA, SOLITARY FORM, ORAL MUSCLES OF THE RIGHT SIDE, VIEWED FROM WITHIN. FROM STREIFF (1908).

The gut forms an elongated loop (fig. 104, *B*), being bent upon itself in a vertical plane, much as in *Traustedtia* (pl. 14). The two limbs of the loop are closely appressed in some individuals, but usually are separated by a slight space. The gut protrudes into a short, but well defined, postabdomen which it fills.

The eye is of the usual horseshoe shape, but shows three slight enlargements, one posteriorly, in the arch of the horseshoe, and one at the tip of each limb of the horseshoe.

There are no ganglionic outgrowths, but the gland shows the usual condition, consisting of a disk-shaped chamber on each side, connected by a convoluted tube with the pharyngeo-cloacal chamber.

The test protrudes to form several pairs of spines (fig. 104), a large postero-lateral pair containing a considerable tube of mantel epithelium, a smaller lateral pair dorsal to these, into the base of which there is a faint evagination of the mantle, and a weakly developed anterior pair, at the angles of the mouth, which show a distinct mantle evagination and but slight protrusion of the test. These structures are doubtless comparable to the postero-lateral protrusions of *Thetys* (fig. 114, p. 122) and *Ritteria hexagona* (fig. 35, p. 63) and to the numerous "tentacles" of *Traustedtia* (pl. 14).

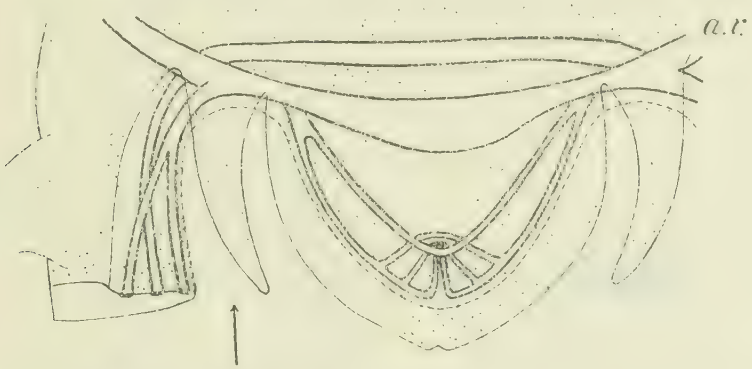

FIG. 106.—THALIA DEMOCRATICA, SOLITARY FORM, DORSAL VIEW OF ATRIAL MUSCULATURE. THE ATRIAL SIPHON WAS CUT ON THE VENTRAL MID LINE, AND THE LEFT FLAP THUS FORMED IS LAID OUT LATERALLY, THE RIGHT FLAP IS OMITTED. FROM STREIFF (1908).

THALIA DEMOCRATICA, aggregated zoöid, Atlantic Ocean form.

The asymmetry of the aggregated *Thalia democratica* is slight (fig. 107, *B*) being noticeable chiefly in the asymmetrical position of the cloacal aperture and the presence of a lateral protuberance of both test and mantle on one side of the posterior end of the body, much as in *Salpa maxima* (fig. 67, p. 85).

There are four body muscles, continuous across the dorsal mid line, but widely interrupted ventrally. I, II, and III are in contact on the dorsal mid line. Muscle IV is branched, as the last body muscle is in the aggregated zooids of other species. Its posterior branch is delicate. It passes by the base of the atrial siphon, but does not extend more than halfway around the latter. Of course, then, it does not meet its fellow of the opposite side or form any visceral muscle.

The intermediate muscle is well developed (figs. 107, *A*, and 108). It is divided into an anterior and a posterior division. The posterior of these arises a little at one side of the mid-ventral line, in front, and

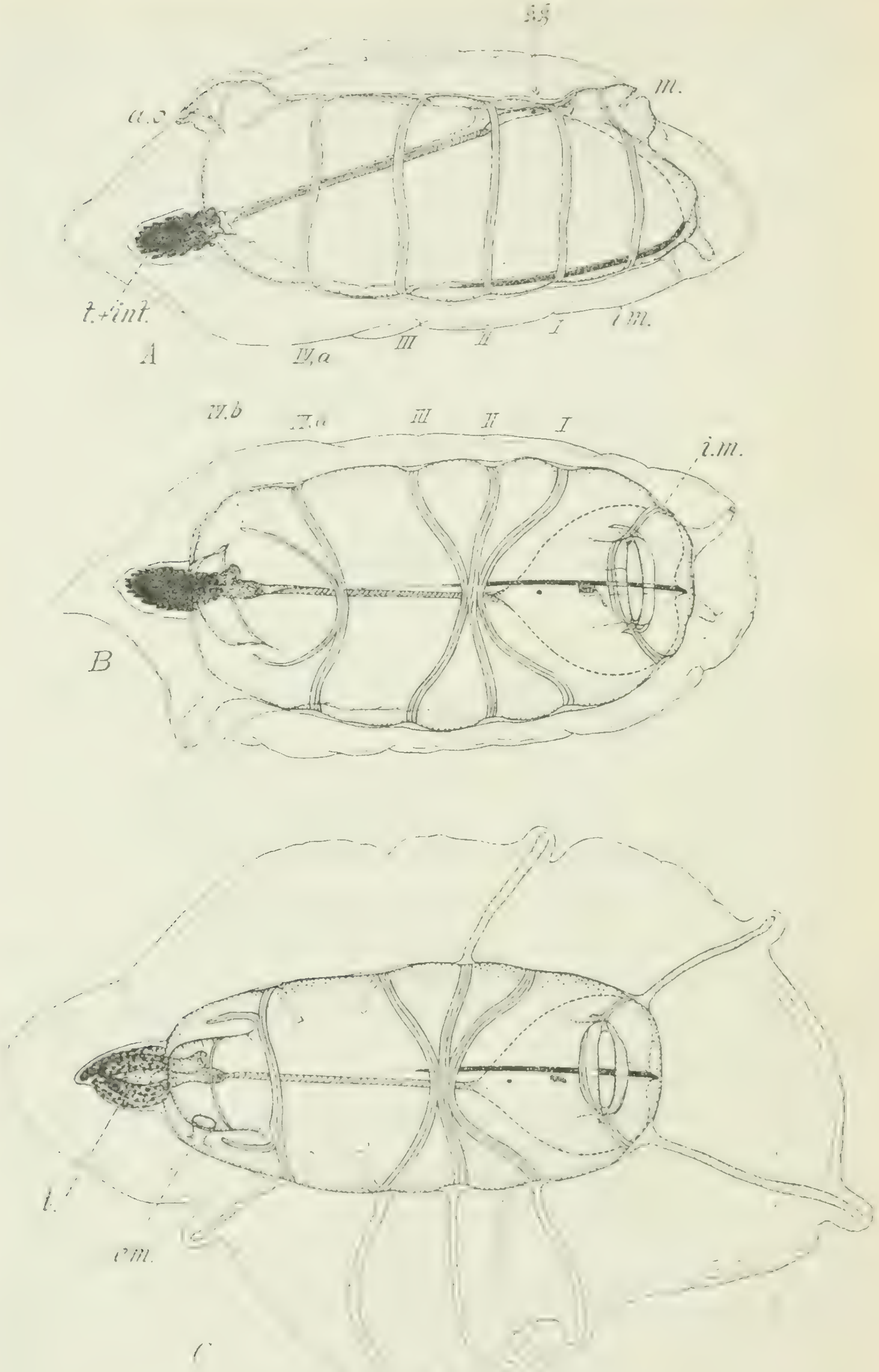
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FIG. 107.—THALIA DEMOCRATICA, AGGREGATED ZOÖIDS. × 3⅓ DIAMETERS. *A*, AN INDIVIDUAL FROM THE RIGHT SIDE OF THE STOLON, VIEWED FROM THE RIGHT SIDE; *B*, A DORSAL VIEW OF AN INDIVIDUAL FROM THE LEFT SIDE OF THE STOLON; *C*, A DORSAL VIEW OF A NEW WESTERN PACIFIC FORM OF THE SAME SPECIES. *A* AND *B* REPRESENT THE PREVALENT ATLANTIC FORM.

runs obliquely upward and backward, past the oral retractor muscle, and stops before reaching the dorsal surface. The anterior division follows the same course, but ends just short of the oral retractor muscle. The basal sphincter of the upper lip (*u.* 3) is a broad band which at first sight seems to be a continuation dorsally of the anterior division of the intermediate muscle. Closer inspection, however, shows it to be distinct from, though it abuts upon, the intermediate muscle. The short oral retractor muscle is continued forward into the first and second sphincters of the upper lip and the first and third sphincters of the lower lip. The second and fourth sphincters of the lower lip are united at the angle of the mouth, lying a little ventral to the oral retractor. They might be said to form a very short ventral division of the oral retractor muscle.

The cloacal musculature (fig. 109) differs in different individuals. My specimens from the eastern and western Pacific Ocean (*A*) agree with Streiff's description (*D*), except as to the internal or external position of the overlapping muscles. Those from the Atlantic coast of New England (*B* and *C*) present slightly divergent conditions, none of which agrees exactly with the Pacific specimens, though some differ only minutely. For the Pacific type I copy Streiff's figure, modifying only the overlapping of the muscles, which I find not as Streiff shows. For the New England coast specimens I twice again modify Streiff's figure to show two of the several variants, one of which (*C*) most nearly approaches the Pacific type, and another (*B*) which is more unlike the Pacific specimens. In general the internal or external position of muscles which overlap is constant in other species of Salpidae. It is therefore a little surprising to find discrepancy in this regard between Streiff's specimens and mine. The divergence in the grouping and attachment of the muscles is no more than might be expected in this very widely distributed and very abundant species. It is of some interest that in my very abundant material from both the Atlantic and Pacific Oceans, the Atlantic animals should show considerable diversity in the cloacal muscles, while the Pacific animals show almost none.

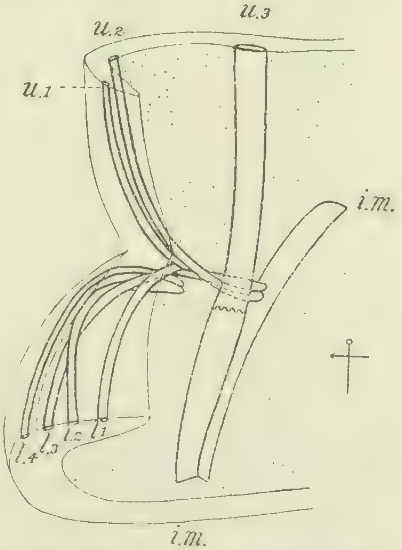

FIG. 108.—THALIA DEMOCRATICA, AGGREGATED FORM, ORAL MUSCLES OF THE RIGHT SIDE SEEN FROM WITHIN. STREIFF (1908).

The gut is more compact than in the solitary form. The endostyle, in both solitary and aggregated forms, is confined to the anterior half of the body, being shorter even than in *Thalia longicauda.* The aggregated *Iasis zonaria,* also, has the endostyle short and in the anterior part of the body. In all three of these species there is a considerable gap between the posterior end of the endostyle and the intestine. In *Pegea confederata* the endostyle is short and in the anterior part of the body, but the gap between the intestine and endostyle, especially in the solitary form, is less marked.

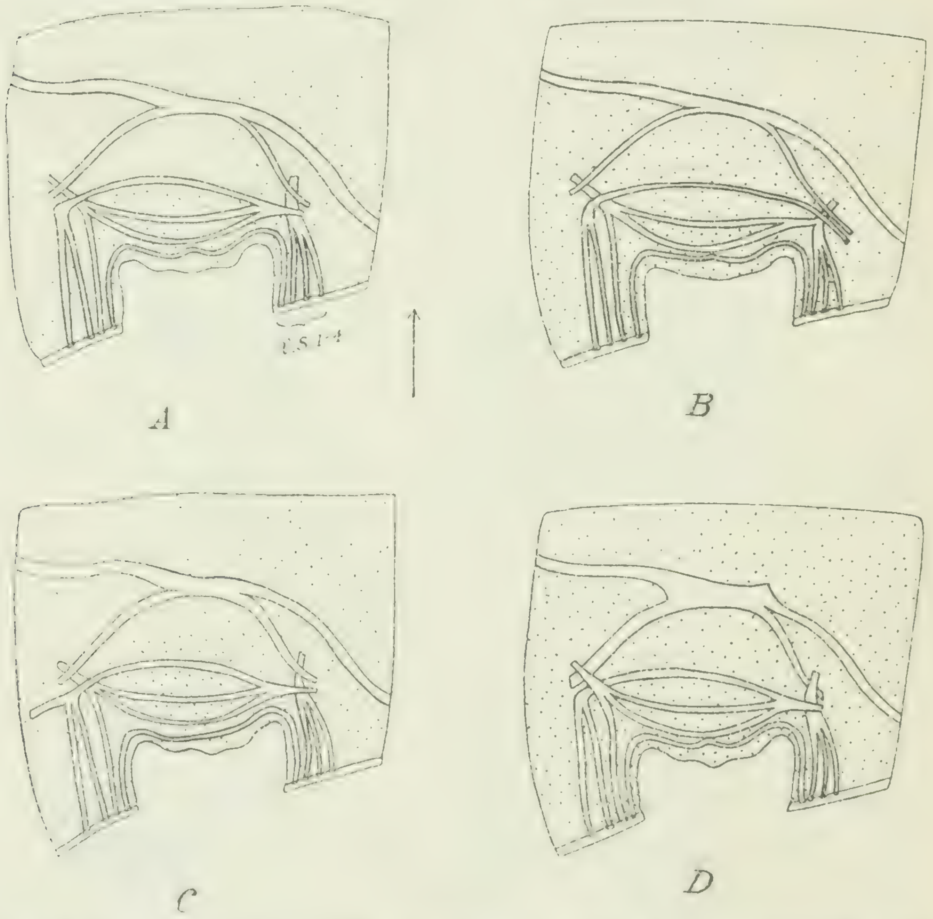

FIG. 109.—THALIA DEMOCRATICA, AGGREGATED FORM, DORSAL VIEWS OF ATRIAL SIPHONS WHICH HAVE BEEN CUT OPEN ON THE MID-VENTRAL LINE AND THE FLAPS LAID OUT LATERALLY: *A*, FROM A PACIFIC OCEAN SPECIMEN; *B*, FROM A NEW ENGLAND COAST FORM; *C*, FROM A SPECIMEN COLLECTED OFF NEWPORT, RHODE ISLAND; *D*, COPIED FROM STREIFF (1908).

The eyes of the aggregated *Thalia democratica* (figs. 110, 111, and 112) are very different from those of the other subgenera, but the structural conditions and the development indicate the homologies. Three distinct portions of the eye are seen on the antero-ventral surface of the ganglion, an anterior, larger portion (*ex*), and two somewhat asymetrical posterior portions (*e'1* and *e'2*). The probable homologies appear when we realize that the anterior rotation of the eye, observed in the development of *Cyclosalpa pinnata* (fig. 12, p. 25) occurs in the same way in *Thalia democratica* but has gone about one hundred and twenty degrees further, the ganglion itself sharing in this rotation, as is clearly shown by the development of the eye and ganglion in the buds and by the arrangement in the adult of the ectodermal epithelium over the originally dorso-anterior face of the ganglion, which is now ventral. If, in imagination, we rotate the ganglion back one hundred and twenty degrees to a position comparable to that in, say, *Salpa fusiformis* (fig. 79, p. 92), we see that in position relative to the ganglion, and in the relative position of the rod and pigment cells, the anterior portion of the eye in *Thalia democratica* (*ex*) is comparable to the large accessory eye (*ex*) in the ganglion of *Salpa fusiformis*. Its pigment layer, present in *Thalia*, is wanting in *Salpa*. The two posterior portions of the *Thalia* eye (*e'1* and *e'2*) represent, then, the large dorsal eye of the true *Salpae*, or rather the proximal portion of this eye, as is shown by the position of rod-cells and pigment cells. The division of this eye into two parts, right and left, is a reversion to the condition seen in *Cyclosalpa pinnata* (figs. 7 and 8, pl. 2), in which the proximal portion of the large dorsal eye is divided into distinct right and left limbs. The innervation of the portions of the eye in *Thalia* agrees with this interpretation. The anterior portion (*e''*) of the large dorsal eye, found in *Cyclosalpa pinnata* and in the other species thus far described in this paper, is lacking in *Thalia*, as is also the optic plug (*e'''*). That portion of the eye which is marked *e'2* is seen to be oriented slightly differently from the portion marked *e'1*. The meaning of this difference in orientation is not clear. It may have to do with the position of the zooid in the chain.

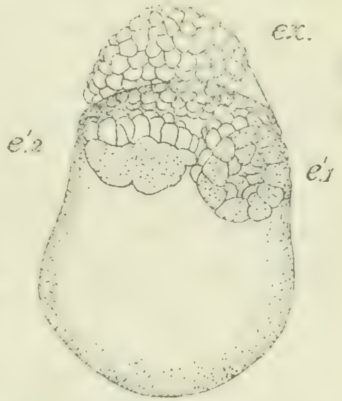

FIG. 110.—THALIA DEMOCRATICA, AGGREGATED FORM, DORSAL VIEW OF GANGLION AND EYES. × 362 DIAMETERS FROM METCALF (1893, c).

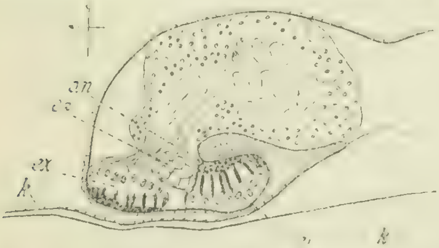

FIG. 111.—THALIA DEMOCRATICA, AGGREGATED ZOÖID; LONGITUDINAL VERTICAL SECTION THROUGH THE GANGLION AND EYES. × 300 DIAMETERS. FROM METCALF (1893, c).

Neither in the fully formed aggregated individuals of *Thalia democratica*, nor in the course of their development, are there any traces of outgrowths from the ganglion, or of either the chambers or the ducts of the neural glands. The remarkable absence of these organs in this species may be associated with the great rotation of the ganglion. It is of interest as showing that these organs are not of indispensable physiological importance in the Salps, for this species, which lacks these organs, is the most abundant and widely distributed of all the species in the family.

THALIA DEMOCRATICA, aggregated zoöid: Philippine form.

Characteristic specimens of the Philippine form of aggregated zooids of this species are in the collections of United States National Museum as follows:

Cat. Nos. 6473 (Holotype) and 6474 (Paratype) U. S. N. M. (Aggregated, Philippine form), *Albatross* station D. 5456; June 7, 1909; 142 fathoms; surface temperature, 86° F.; two specimens.

In the prevalent form of the aggregated zooids of *Thalia democratica* from the Atlantic coast of the United States (fig. 107, *A* and *B*) there are but few tubular protuberances of the mantle into the test. At one of the postero-lateral angles of the body there is one which protrudes slightly beyond the general contour of the test. There are generally an unequal pair in front not protruding beyond the general contour of the test. If there are others they are generally weakly developed.

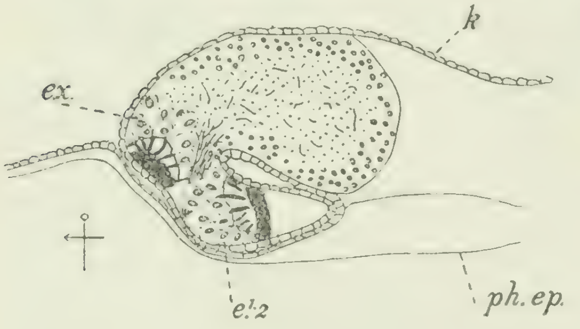

FIG. 112.—THALIA DEMOCRATICA, AGGREGATED FORM, LONGITUDINAL VERTICAL SECTION OF GANGLION AND EYES, SHOWING THE INNERVATION OF $e^{1,2}$. × 300 DIAMETERS. FROM METCALF (1893, *c*).

On the other hand, in the Philippine collections of this species, made by the Bureau of Fisheries steamer *Albatross*, there are very numerous specimens of a form of aggregated zooid, which show more numerous and much more developed mantle protuberances (fig. 107, *C*). This zooid strikingly resembles *Traustedtia radiata* in musculature, form of "nucleus," and "tentacles." This resemblance is so marked that one, at first glance, thinks these zooids to be the aggregated form of the latter species. The testis in these aberrant Philippine zooids is readily seen to be in the form of four lobes surrounding the intestine.

Among the Atlantic specimens are some which, in the number of mantle protuberances, approach the Philippine type, but I have found none with the protuberances so well developed as in the latter.

Our collections from the Philippines, on the other hand, contain numerous individuals of the prevalent Atlantic type, having the mantle protuberances few in number (though rather too long to be characteristic), having the lobes of the testis subdivided into numerous lobules, and having the test behind the intestinal "nucleus" pointed instead of rounded. There seems to be rather complete intergradation between the two types. It seems hardly worth while to give them distinct varietal names.

From study of the smallest (youngest) of the aggregated zooids of the Philippine type one point of interest in the development of the eye is seen. In an early stage of its development, those portions of the eye marked e'_1 and e'_2 in figures 110, 111, and 112, are united into one, and the eye is thus in two instead of three divisions. In *Cyclosalpa pinnata* buds the eye is at first horseshoe-shaped, the hollow of the horseshoe soon becoming filled; later the posterior portion of the inverted disk becomes again divided into two limbs. In *Thalia democratica* the latter two stages are the only ones I have found, the eye of the aggregated zooid appearing, in the earliest stage I have seen, as a disk not a horseshoe. In other species of Salpidae the final stage, involving splitting of the posterior part of the inverted disk into two limbs, is omitted.

THALIA LONGICAUDA (Quoy and Gaimard, 1824).

Salpa longicauda QUOY AND GAIMARD, 1824.
S. democratica-mucronata, var. *flagellifera* TRAUSTEDT, 1885.
S. flagellifera APSTEIN, 1894, *a*.

Of this species I have had no specimens. It is very similar to *Thalia democratica*, being distinguished by the presence of two unusually long and slender appendages from the posterior angles of the body in the solitary form (fig. 113); by having the body muscles not continuous across the ventral line in the solitary form; by the independence, in the solitary form, of all the body muscles, which are not united dorsally into two groups as in the solitary *Thalia democratica;* and by the fact that in the aggregated individuals the intermediate muscle and body muscles are composed of more fibers than they are in *Thalia democratica*. Apstein (1906, *a* and *b*) gives the numbers as follows (using my notation).

Body muscle:	*Thalia democratica fibers.*	*Thalia longicauda fibers.*
I.	5	8–11
II.	3–4	6–9
III.	3	8–9
IV, a.	3–4	5–7
IV, b.	2	2

Apstein's body muscle V is here counted as the posterior branch of the body muscle IV.

The oral and atrial muscles of *Thalia longicauda* have not been studied, nor have the neural glands and the outgrowths from the ganglion. The eye of the aggregated form has not been observed. Dober (1912) gives a figure of the eye of the solitary form showing little detail, but apparently indicating that the pigment is in three divisions corresponding to the enlargements of the eye in the ordinary *Thalia democratica.*

The Thalias are a sharply demarcated subgenus. They grade into the other subgenera less even than do the Cyclosalpas. This is shown especially in the character of the eyes and the absence of neural glands and outgrowths from the ganglion in the aggregated zoöids, but the subgenus is recognizably distinct also in the character of its appendages and of the tubular protuberances from the mantle into the test. In the latter two features it shows some general resemblance to *Traustedtia.*

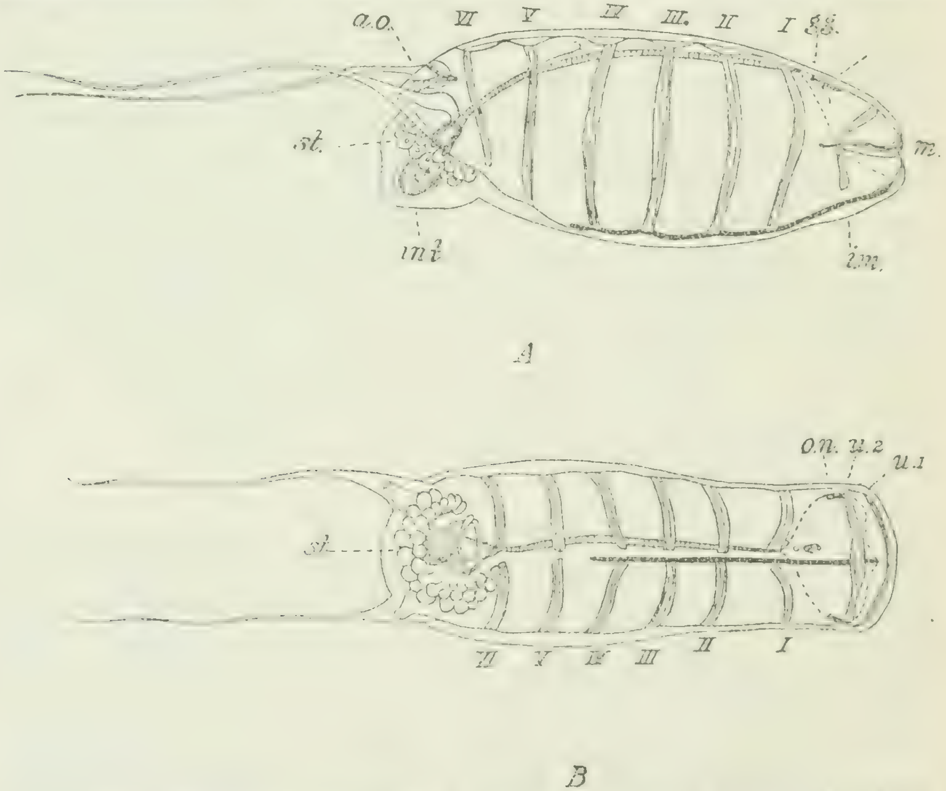

FIG. 113.—THALIA LONGICAUDA, SOLITARY FORM: *A*, VIEW FROM THE SIDE; *B*, VENTRAL VIEW. FROM TRAUSTEDT (1885).

We have one bit of evidence that aids us in determining which of the two species of *Thalia* is the more archaic. In studying the development of the buds upon the stolon of *Thalia democratica*, one sees that the body muscle bands arise as regularly spaced loops and that only late in the development do they become approximated dorsally into two groups of three and two respectively. This shows that, as one would naturally expect, the condition with dorsally approximated body muscles is secondary. If this is true for the aggregated zoöids, it is doubtless true also for the solitary individuals. *Thalia longicauda*, with its regularly spaced body muscles in the solitary form, is therefore to be regarded as more archaic than *Thalia democratica* with its body muscles in the solitary form approximated dorsally into two groups.

SUBGENUS THETYS Tilesius, 1802.

THETYS VAGINA Tilesius, 1802.

Salpa tilesii CUVIER, 1804.
Dagysa strumosa HOME, 1814.
"Another species" HOME, 1814.
Salpa costata QUOY and GAIMARD, 1824.
S. bigibbosa QUOY and GAIMARD, 1824.
S. gibbosa QUOY and GAIMARD, 1824.
S. herculea DALL, 1872.
S. infundibuliformis QUOY and GAIMARD, 1824.
(?) *S. neapolitana* DELLE CHIAJE, 1841.
S. costata-tilesii KROHN, 1846, and more recent authors.
Iasis costata-tilesii HERDMAN, 1891.
Salpa vagina IHLE, 1911.

To the subgenus *Thetys* may be assigned the single species *vagina* (*Salpa tilesii* of most authors), the largest of the Salpidae. I have had two very good specimens of the solitary form besides several degenerate specimens. Of the aggregated form I have had about fifty specimens from six localities. Specimens of this species are found in the United States National Museum collections as follows:

Cat. No. 6438, U.S.N.M. (solitary form), *Albatross* station D. 5441, S. Fernando Point Light, west coast of Luzon; May 10, 1909; 186 fathoms; surface temperature, 87° F.; one specimen.

Cat. No. 6426, U.S.N.M. (aggregated form), *Albatross* station D. 3132, off Point Conception, California, March 14, 1890; 33 fathoms; surface temperature, 55° F.; one specimen.

Cat. No. 6427, U.S.N.M. (aggregated form), *Albatross* station D. 2402, Gulf of Mexico, March 14, 1885; 111 fathoms; one specimen.

Cat. No. 6515, U.S.N.M. (solitary form), *Albatross* station D. 5243, Pujada Bay and vicinity, Philippine Islands; May 15, 1908; surface; surface temperature, 84–85° F.; surface density 1.02453; eight specimens.

Cat. No. 6518, U.S.N.M. (tests of solitary and also aggregated form), *Albatross* station D. 5242, Pujada Bay and vicinity, Philippine Islands; May 14, 1908; surface; surface temperature, 85° F.; surface density, 1.02457; 44 specimens.

Cat. No. 6552, U.S.N.M. (test), *Albatross* station D. 5569, north of Tawi Tawi, Philippine Islands; September 22, 1909; surface; surface temperature, 83° F.; one specimen.

Cat. No. 6585, U.S.N.M. (test of solitary form), *Albatross* station D. 5244, Pujada Bay and vicinity, Philippine Islands; May 15, 1908; surface; surface temperature, 85° F.; surface density, 1.02497; 3 specimens.

Cat. No. 6609, U.S.N.M. (solitary form. Tests), *Albatross* station D. 5241, Pujada Bay and vicinity, Philippine Islands; May 14, 1908; surface; surface temperature, 85° F.; surface density, 1.02453; 10 specimens.

Cat. No. 6610, U.S.N.M. (aggregated form), *Albatross* station D. 5243, Pujada Bay and vicinity, Philippine Islands; May 15, 1908; surface; surface temperature, 84-85° F.; surface density, 1.02453; one specimen.

THETYS VAGINA, solitary form.

Like some of the Ritterias, the solitary form of this species has a variable number of body muscles (fig. 114). The number is about the same as in *Ritteria picteti*, 16 to 20, or more. All the muscles are interrupted on the dorsal mid line, and many of the anterior and some of the posterior ones are also interrupted dorso-laterally. The muscles barely extend onto the ventral half of the body.

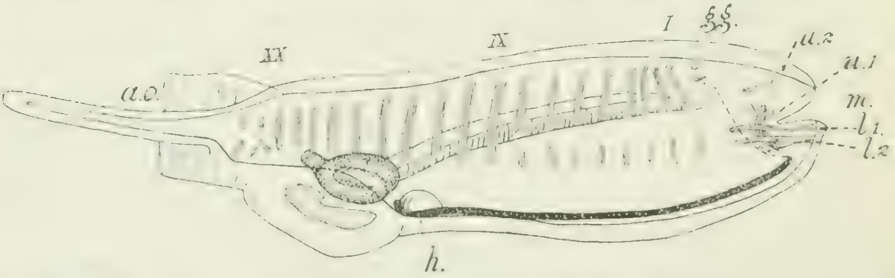

FIG. 114.—THETYS VAGINA, SOLITARY FORM, VIEWED FROM THE RIGHT SIDE, ONE-HALF NATURAL SIZE. MODIFIED FROM RITTER (1906).

The intermediate muscle (fig. 115) is reduced to a mere vestige at the angle of the mouth.

The oral muscles are rather weakly developed for such a huge salpa. In two specimens I have had for study the conditions are somewhat different. The relations in the smaller individual are shown in figure 114. Those in the larger individual appear in figure 115. In the first figure the inverted portion of the lower lip is drawn forward to the outer surface. In the second figure the natural relations are shown. Two oral retractor muscles are present, each continued forward into a well-developed sphincter of the lower lip (*l. 2* and *3*). In the smaller specimen (fig. 114) these are distinct; in the larger specimen (fig. 115) they are united through the ventral half of their course. Another very delicate sphincter (*l. 4*) is present in both individuals. In the smaller specimen (fig. 114) it is continuous at its upper end with the ventral edge of the ventral oral retractor and at its other end with the ventral edge of the second sphincter of the lower lip. In the larger specimen (fig. 115) the third sphincter is wholly independent, but its base is connected by a blood sinus with the ventral retractor. In the larger specimen there is an exceedingly delicate first sphincter of the lower lip (*l. 1*), admarginal, which arises from the dorsal edge of the dorsal oral retractor.

The muscles of the upper lip also differ in the two specimens. In the smaller there is a short, but fairly broad, first sphincter (*u. 1*). In the larger individual no corresponding muscle is found, but in its place is the muscle blood sinus (fig. 115). The second sphincter is broad. Like the body muscles, it is interrupted on each side, the interval showing the continuous blood sinus.

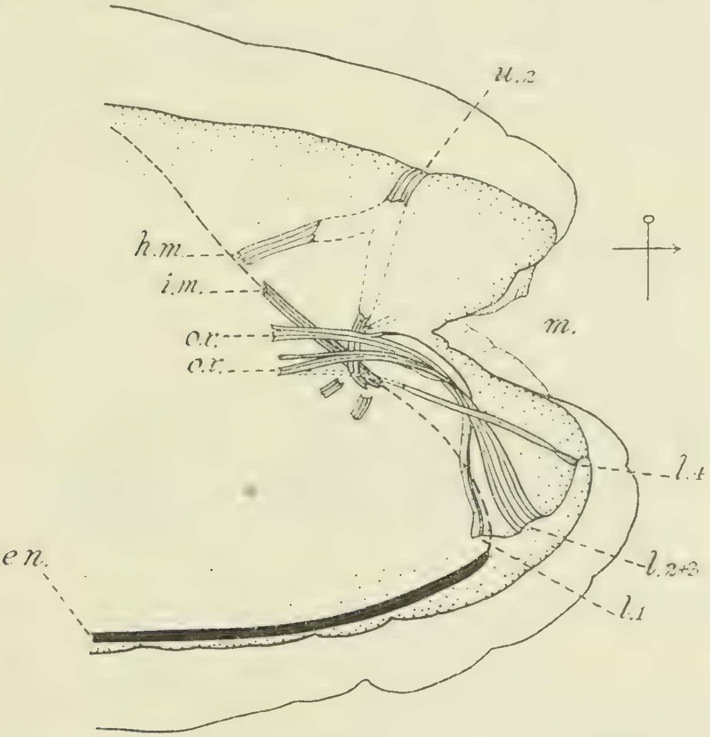

FIG. 115.—THETYS VAGINA, SOLITARY FORM, ORAL MUSCLES SEEN FROM THE RIGHT SIDE. × $1\frac{1}{2}$ DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The dorsal horizontal band is short and independent of other muscles, though it is united to the second sphincter of the upper lip by a blood sinus. The intermediate muscle is short in both specimens. It is shorter in the smaller specimen (fig. 114) and is united to the base of the first sphincter of the upper lip. Postero-ventral to the lower end of the intermediate muscle one sees, in each specimen, two very short problematic muscles entirely disconnected. Comparison with the aggregated zoöid (fig. 117) seems to indicate that these minute muscles are isolated ventral fragments of the sphincters of the upper lip. Compare also the conditions in the solitary *Salpa* *maxima* (figs. 64 and 65, p. 84), in which some specimens show isolated ventral moieties of the intermediate and ventral oral retractor muscles.

Thetys vagina shows very well a feature that often helps in determining the true relation of muscles. Each muscle in a *Salpa* is formed upon a blood sinus, and when a muscle is interrupted the sinus is generally continued across the interval, showing the real relations. In comparing embryos and adult solitary individuals, or younger and older aggregated zoöids, one sometimes finds in one a muscle, while in a corresponding position in the other there is only the muscle blood sinus. The same difference may be observed between divergent adult individuals, as for instance, note the abortive first sphincter of the upper lip (*u. 1*) in figure 114 and the blood sinus in a similar position in figure 115.

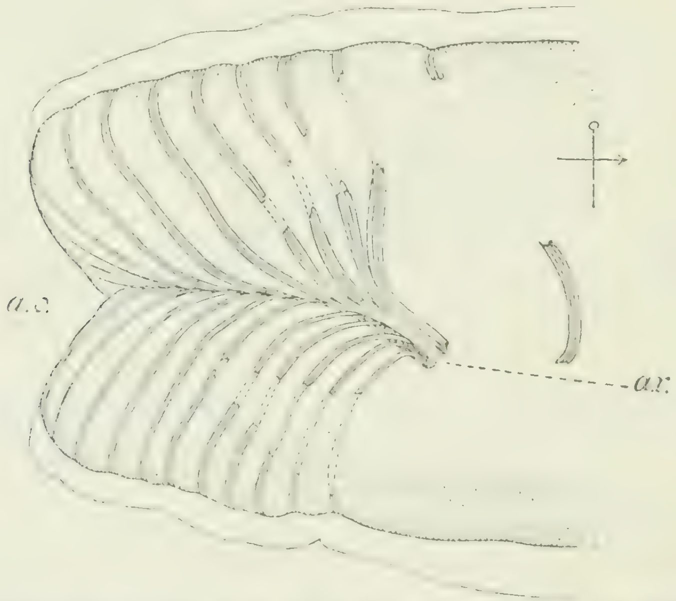

FIG. 116.—THETYS VAGINA, SOLITARY FORM, ATRIAL MUSCLES VIEWED FROM THE RIGHT SIDE. × 3 DIAMETERS. (DRAWN BY HOYT S. HOPKINS.)

The atrial siphon is a broad tube and bears 11 delicate sphincter muscles (fig. 116) on its upper and lower lips. These unite at each angle of the aperture to form a rather weakly developed short atrial retractor muscle. For so large an animal the whole musculature is very weak. There are lateral interruptions of several of the atrial sphincters, both above and below the retractor.

From near the posterior end of the body there protrudes, on each side, a cylindrical curved protuberance, generally from a fourth to a fifth as long as the whole body (fig. 114). This contains a tube whose epithelial walls are continuous with the mantle epithelium. These tubular protuberances closely resemble the "tentacles" of *Traustedtia* (pl. 14), even in the peculiar appearance of the enlarged tips of the inner tubes. Protuberances of the test at the posterior angles of the body are found in numerous species, and in many of these species they contain tubes whose epithelial lining is continuous with the mantle.

The gut is a round coil which may be called a "nucleus," though it is less densely compacted than in the *Apsteinias* and *Salpas*. One can make out the course of the intestine without dissection.

I have not had sufficient material to study the histology of the neural organs and gland. Examination of total preparations shows the eye to be of the usual horseshoe form.

THETYS VAGINA, aggregated form.

There are five body muscles (fig. 117), all narrowly interrupted dorsally and extending laterally only to the sides of the body. The ventral half of the body has no muscles of any sort. The fifth body muscle is divided on each side into an anterior and a posterior branch, as in the aggregated forms of other species, but the posterior branches are short and do not pass below the atrial siphon or give rise to any visceral muscle.

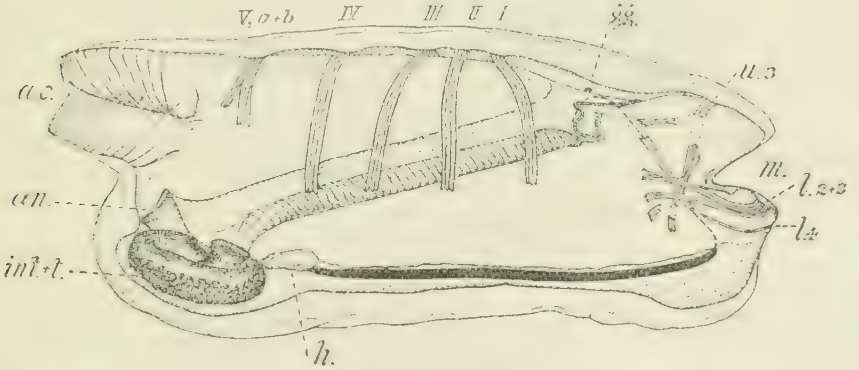

FIG. 117.—THETYS VAGINA, AGGREGATED ZOÖID VIEWED FROM THE RIGHT SIDE, $\frac{3}{4}$ NATURAL SIZE. (DRAWN BY HOYT S. HOPKINS.)

The intermediate muscle is as in the larger of my specimens of the solitary form of this species, not being fused with the rudimentary first sphincter of the upper lip. The oral musculature, including the horizontal dorsal band, is like that of the solitary form, except that there are three, instead of two, dorsal sphincters, the first very short and very slender, the second also very short. The musculature of the atrial siphon, also, is like that of the solitary form, except that there are 12 to 15, instead of 11, sphincters in my specimens. On the dorsal side the basal sphincter is widely interrupted in the middle, and ventrally its ends do not come into contact with the atrial retractor muscle.

The gut, in the aggregated as in the solitary form, is a close coil, but one can readily trace the course of the intestine, except that the overlying test is usually very dense and somewhat opaque.

In no species of Salpidae is the pocket valve structure of the lower lip clearer than in the aggregated *Thetys vagina.*

The aggregated form of *Thetys vagina* has a large dorsal eye and two large masses of optic cells in the ganglion (fig. 118), in all of which the rod cells are irregularly polyhedral in shape, not elongated, and their walls are unevenly thickened to form the rod-like materials In the large dorsal eye, two portions may be distinguished, a basal portion with pigment ventral to the rod cells, and an apical portion whose pigment is dorsal to the rod cells, thus showing resemblance to the eye in the true *Salpae*, except for the degenerate condition of the rod cells in *Thetys*. The eye of *Thetys* is short and compact, as in *Iasis zonaria*, (figs. 101 and 102, p. 108), and the pigment layers of its basal and apical portions are continuous at the sides of the eye but not on the mid-ventral line. The section figured is parasagittal, not sagittal, and shows the pigment of the two regions continuous.

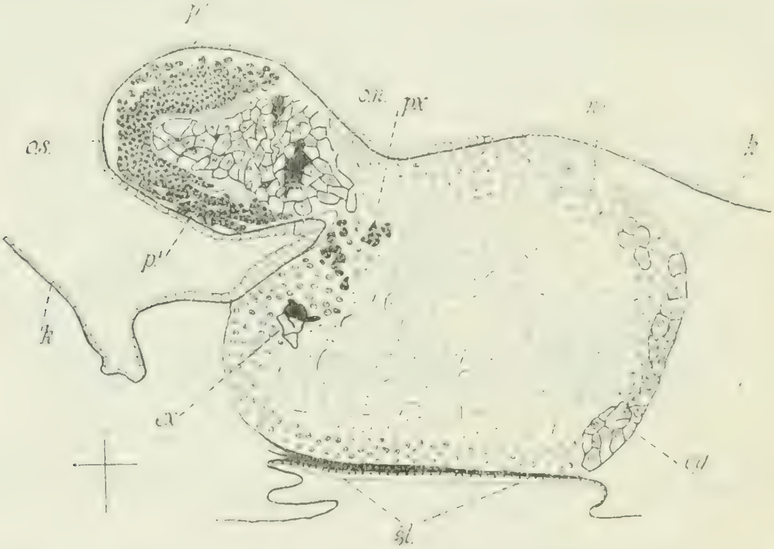

FIG. 118.—THETYS VAGINA, AGGREGATED FORM, SAGITTAL SECTION OF GANGLION, DORSAL EYE, AND NEURAL GLAND. × 98 DIAMETERS. FROM METCALF (1893, c).

In the ganglion are two large masses of irregular rod cells, as indicated by the rod-like material of which their unevenly thickened wall. are composed. The larger of these masses covers the whole postero-ventral face of the ganglion and is probably homologous with the posterior pair of smaller eyes in the ganglion of *Cyclosalpa pinnata*. In the interior of the ganglion, below its antero-dorsal surface, is a considerable mass of similar irregular rod cells and just dorsal to them is a mass of pigment cells.[1] *Thetys* is noteworthy in having abundant pigment associated with the antero-dorsal eye within the ganglion.

The neural gland in the aggregated zoöids of *Thetys vagina* (fig. 118) is unique. Instead of two disks below the ganglion, each opening by a tube to the peripharyngeal chamber, there is a single huge evagination of this chamber, with a single wide median aperture- The epithelium of that part of the evagination which is in contact with the ganglion is thickened and resembles the dorsal portion of the epithelium of the glandular disks in other species. Remembering the origin of the typical disks in other species, as paired evaginations from the pharyngeo-cloacal epithelium, it is not so great a divergence from the usual conditions, which *Thetys* shows. Instead of two evaginations, one right and the other left, *Thetys* has a single huge median evagination, and this does not develop far enough to close off from the pharyngeo-cloacal chamber. In *Iasis zonaria* there is a single postero-median chamber in the neural gland (fig. 103, p. 108) but this shows paired anterior prolongations. There is also but one duct, but this is lateral, one duct being present and the other absent. [*Cf. Salpa cylindrica* Metcalf, 1893, *c.*] In *Thetys* the gland is further modified and it and its single aperture are median.

Like *Iasis*, the aggregated zoöid of *Thetys* bears several embryos.

Subgenus PEGEA, (Savigne 1816).

PEGEA CONFEDERATA, (Forskål 1775).

Salpa confederata FORSKÅL, 1775.
S. gibba BOSC, 1802.
S scutigera CUVIER, 1804.
S. octophora CUVIER, 1804.
S. vivipara PERON, 1807.
Pegea octophora SAVIGNY, 1816.
Salpa ferruginea CHAMISSO, 1819.
S. informis QUOY AND GAIMARD, 1824.
Salpa femoralis QUOY AND GAIMARD, 1826–1834.
S. quadrata HERDMAN, 1888.
Pegea scutigera-confederata HERDMAN, 1891.
S. confederata APSTEIN, 1894, *a*.

In the collections of the United States National Museum there are the following specimens:

Cat. No. 6433 U.S.N.M. (solitary form), *Albatross* station D. 4037, Kawaihae Strait, Penguin Bank, south coast Oahu Island, Hawaiian Islands; July 10, 1902; surface; surface temperature 80° F.; 1 specimen.

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[1] It is noteworthy to find these pigment cells *within* the ganglion instead of superficial as in the case of the eyes of the aggregated zoöids of all other species. In the eyes of some solitary *Salpae*, the pigment cells are within the optic ridge, instead of just beneath the epithelium, as in *Cyclosalpa pinnata* (fig. 4, p. 17). I am unable to say whether these internal pigment cells are mesodermal, as the superficial pigment cells in the eyes of aggregated zoöids seem to be.

Cat. No. 6435, U.S.N.M. (solitary form—i. e., large embryo), *Albatross* H. 543, south of Marthas Vineyard; surface; 1 specimen.

Cat. No. 6436, U.S.N.M. (embryo), *Albatross* (No. 127), 70 miles off Point Galera, Ecuador; 20 + specimens.

Cat. No. 6467, U.S.N.M. (aggregated form), *Albatross* collection, Jolo anchorage, February 8, 1908; 10 + specimens.

Cat. No. 6467, U.S.N.M. (aggregated form), Jolo Archipelago, Philippine Islands; February 8, 1908; surface; 30 + specimens.

Cat. No. 6514, U.S.N.M. (aggregated form and large embryo), *Albatross* station D. 5234, between Bohol and Leyte, Philippine Islands; May 7, 1908; surface; surface temperature, 84° F.; surface density, 1.02531; 20 + specimens.

Cat. No. 6523, U.S.N.M. (solitary form, rare), *Albatross* station D. 5144, vicinity of Jolo, Philippine Islands; February 15, 1908; surface; surface temperature 81° F.; surface density, 1.02514; 1 + specimen.

Cat. No. 6529, U.S.N.M. (embryo), *Albatross* station D. 5234, between Bohol and Leyte, Philippine Islands; May 7, 1908; surface; surface temperature, 84°; surface density, 1.02531; 3 specimens.

Cat. No. 6533, U.S.N.M. (aggregated form and embryo), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 25 + specimens.

Cat. No. 6535, U.S.N.M. (solitary form, rare; also aggregated form), *Albatross* station D. 5553, Jolo Island and vicinity, Philippine Islands; September 17, 1909; surface; surface temperature, 83° F.; 2 specimens.

Cat. No. 6562, U.S.N.M. (embryo), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 2 specimens.

Cat. No. 6563, U.S.N.M. (aggregated form), *Albatross* station D. 5196, off northern Cebu Island, Philippine Islands; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; 1 specimen.

Cat. No. 6564, U.S.N.M. (aggregated form), *Alabtross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay-Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 1 specimen.

Cat. No. 6565, U.S.N.M. (solitary form, rare), *Albatross* station D. 5578, North of Tawi Tawi, Philippine Islands; September 23, 1909; surface; surface temperature, 82° F.; 1 specimen.

Cat. No. 6566, U.S.N.M. (aggregated form), *Albatross* station D. 5530. Between Siquijor and Bohol Islands, Philippine Islands; August 11, 1909; surface; surface temperature, 84° F.; 1 specimen.

Cat. No. 6567, U.S.N.M. (embryo), *Albatross* station D. 5456, East coast of Luzon, San Bernardino Strait, to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 1 specimen.

Cat. No. 6572, U.S.N.M. (aggregated form and embryo), Labuan Blanda Island, Philippine Islands; December 13, 1909; surface; 28 specimens.

Cat. No. 6573, U.S.N.M. (aggregated form), Bubuan Island. Anchorage. Jolo, Philippine Islands; February 14, 1908; surface; 33 specimens.

Cat. No. 6586, U.S.N.M. (aggregated form), *Albatross* station D. 5561. Jolo Island and vicinity, Philippine Islands; September, 18 1909; surface; surface temperature, 82° F.; 2 specimens.

Cat. No. 6593, U.S.N.M. (aggregated form and embryo), *Albatross* station D. 5540. Between Negros and Siquijor, Philippine Islands; August 19, 1909; surface; surface temperature, 83° F.; 50 + specimens.

Cat. No. 6594, U.S.N.M. (aggregated form), *Albatross* station D. 5196. Off northern Cebu Island, Philippine Islands; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; 13 specimens.

Cat. No. 6595, U.S.N.M. (aggregated form and embryo), *Albatross* station D. 5539. Between Negros and Siquijor, Philippine Islands; August 19, 1909; surface; surface temperature, 83° F.; 25 + specimens.

Cat. No. 6596, U.S.N.M. (aggregated form), Jolo, Philippine Islands; February 10, 1908; surface; 12 + specimens.

Cat. No. 6597, U.S.N.M. (aggregated form), *Albatross* station D. 5456. East coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 30 + specimens.

Cat. No. 6598, U.S.N.M. (aggregated form), *Albatross* station D. 5604. Gulf of Tomini, Celebes; November 15, 1909; surface; surface temperature, 83° F.; 10 + specimens.

Cat. No. 6599, U.S.N.M. (aggregated form), *Albatross* station D. 5663. Macassar Strait, Philippine Islands; December 27, 1909; surface; surface temperature, 84° F.; 4 specimens.

Cat. No. 6600, U.S.N.M. (aggregated form), *Albatross* station D. 5616, Molucca Passage, Philippine Islands; November 22, 1909; surface; surface temperature, 84° F.; 5 + specimens.

Cat. No. 6601, U.S.N.M. (aggregated form), China Sea, vicinity southern Luzon; July 20, 1908; surface; 2 specimens.

Cat. No. 6602, U.S.N.M. (aggregated form), *Albatross* station D. 5540, between Negros and Siquijor, Philippine Islands; August 19, 1909; surface; surface temperature, 83° F.; 10 + specimens.

Cat. No. 6603, U.S.N.M. (aggregated form), *Albatross* station D. 5320, China Sea, vicinity Formosa; November 6, 1908; surface; surface temperature, 80° F.; 1 specimen.

Cat. No. 6604, U.S.N.M. (large embryo and small), *Albatross* station D. 5540, between Negros and Siquijor, Philippine Islands; August 19, 1909; surface; surface temperature, 83° F.; 25 + specimens.

Cat. No. 6605, U.S.N.M. (aggregated form), *Albatross* station D. 5140, vicinity of Jolo, Philippine Islands; February 14, 1908; surface; surface temperature, 80°–82° F.; surface density, 1.02477; 5 specimens.

Cat. No. 6606, U.S.N.M. (aggregated form), *Albatross* station D. 5232, between Bohol and Leyte, Philippine Islands; May 7, 1908; surface; surface temperature, 84° F.; surface density, 1.02531; 3 specimens.

Cat. No. 6607, U.S.N.M. (aggregated form), *Albatross* station D. 5456, east coast of Luzon, San Bernardino Strait to San Miguel Bay, Philippine Islands; June 7, 1909; surface; surface temperature, 86° F.; 10 + specimens.

Cat. No. 6608, U.S.N.M. (aggregated form and one large embryo), Bubuan Island anchorage, Philippine Islands; February 14, 1908; surface; 47 + specimens.

The musculature of this species is less developed than in any other of the Salpidae except *Traustedtia*.

PEGEA CONFEDERATA, solitary form.

In the solitary form there are four muscles which should be classed as body muscles, two in front and two posterior, arranged as shown in figure 119. The fifth muscle on the dorsal surface is probably the homolog of the basal atrial sphincter in other species. All these muscles are confined to the dorsal surface. They do not reach even well onto the sides of the body. There is an intermediate muscle (fig. 120) which, as in *Thetys vagina* (fig. 115, p. 123), functions in connection with the oral muscles rather than the body muscles. It is divided lengthwise into an anterior and a posterior band, which are parallel. The dorsal horizontal band on each side is continuous posteriorly with the anterior band of the intermediate muscle. In front it is near to but not in contact with the broad sphincter of the dorsal lip.

The oral musculature (fig. 120) shows a retractor muscle which is divided into dorsal and ventral divisions, the dorsal division having two branches anteriorly. The ventral retractor connects anteriorly with the broad sphincter of the upper lip, the only complete sphincter in this lip. It connects also with the third sphincter of the lower lip. The ventral branch of the dorsal oral retractor is continuous only with the second sphincter of the lower lip.

The dorsal branch of the dorsal oral retractor is continued forward into the first sphincter of the lower lip and also gives rise to a short muscle on each side, which runs up onto the upper lip, as if to form a first admarginal sphincter, but this is incomplete.

The musculature of the atrial siphon is shown in part in figure 121, which is a drawing of the siphon of an embryo cut open on the mid-dorsal line and spread out flat, the drawing showing an exterior (ventral) view of the preparation. Figure 122 shows a similar preparation of the cloacal siphon of an adult, in similar view.

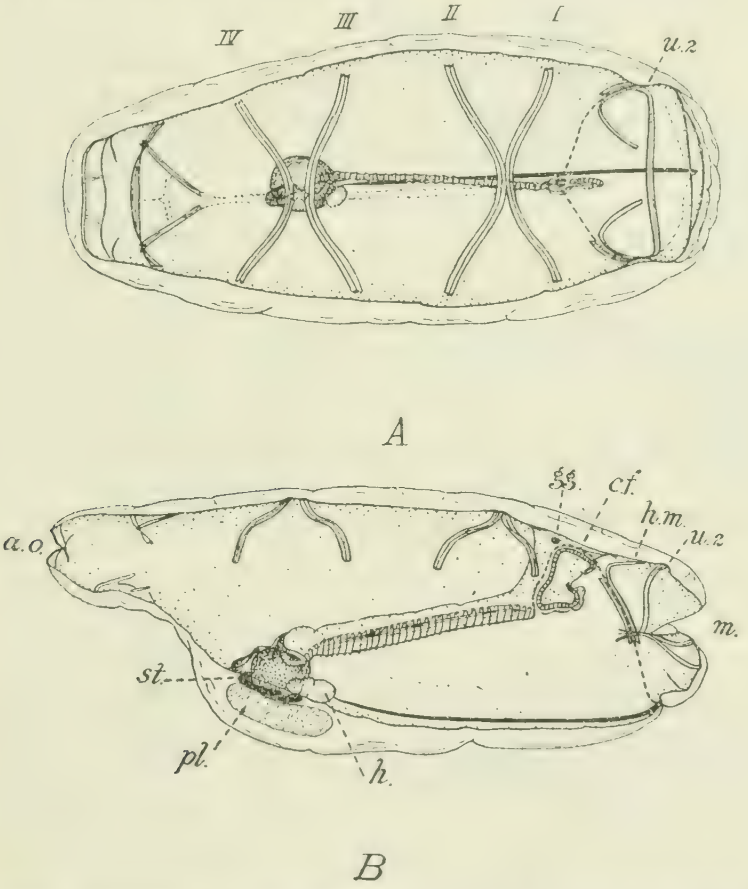

FIG. 119.—PEGEA CONFEDERATA, SOLITARY FORM: *A*, DORSAL VIEW; *B*, VIEW FROM THE RIGHT SIDE. × 2 DIAMETERS. FROM SPECIMENS COLLECTED IN PHILIPPINE WATERS AND OTHERS FROM THE ALASKA COAST. (DRAWN BY HOYT S. HOPKINS.)

Figure 119, *A* and *B*, show additional muscles on the dorsal side at the base of the atrial siphon. These do not appear in figures 121 and 122. There is a slightly developed atrial retractor muscle, continuous, in the embryo, with the second dorsal sphincter, in the adult, with both first and second dorsal sphincters. There are two complete dorsal sphincters and two incomplete, the fourth much reduced in the adult. There are two ventral sphincters, the second being double along the middle portion in the embryo. In the adult the posterior division of the second ventral sphincter separates and lies independent behind the main trunk of the sphincter. There is a weakly developed group of longitudinal fibers at the mid-ventral line, running back from the posterior division of the second ventral sphincter. Across the dorsal surface of the base of the atrial siphon there runs a well-developed muscle band (fig. 119, *A*). This connects on each side with a band which runs forward and toward the median line, reaching about halfway to body muscle IV. These basal atrial muscles of the dorsal surface are not represented in figures 121 and 122. Across the ventral surface of the base of the siphon there is a well-developed muscle band (figs. 119, *B*, 121, 122), a small branch from which on each side

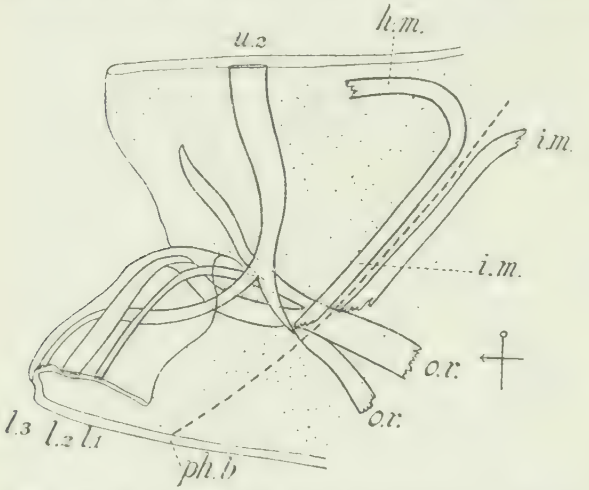

FIG. 120.—PEGEA CONFEDERATA, SOLITARY FORM, ORAL MUSCULATURE OF THE RIGHT SIDE VIEWED FROM WITHIN. MODIFIED FROM STRIEFF (1908). THE ORAL MUSCULATURE OF THE AGGREGATED ZOÖID IS SIMILAR.

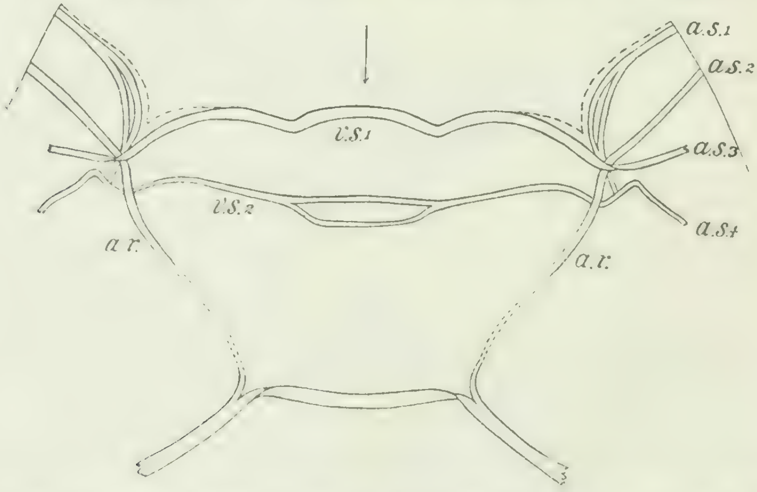

FIG. 121.—PEGEA CONFEDERATA, EMBRYO, ATRIAL MUSCULATURE IN VENTRAL VIEW. THE ATRIAL SIPHON WAS CUT OPEN ALONG THE DORSAL MID LINE AND THE FLAPS LAID OUT LATERALLY. × 150 DIAMETERS.

runs toward the atrial retractor. The end of this branch and the tip of the atrial retractor are connected by a blood lacuna.

The gut, as in the Thalias (fig. 104, p. 111), is a close loop, almost as compact as in the true *Salpae.* The course of the wide intestine can however be made out without dissection.

The eye shows the customary horseshoe form. Its rod-cells are irregularly polyhedral, with unevenly thickened walls, that is, they are degenerate. The neural glands are of the usual type. There are large-celled and small-celled pairs of outgrowths from the ganglion, just above and in front of the disks of the glands.

PEGEA CONFEDERATA, aggregated form.

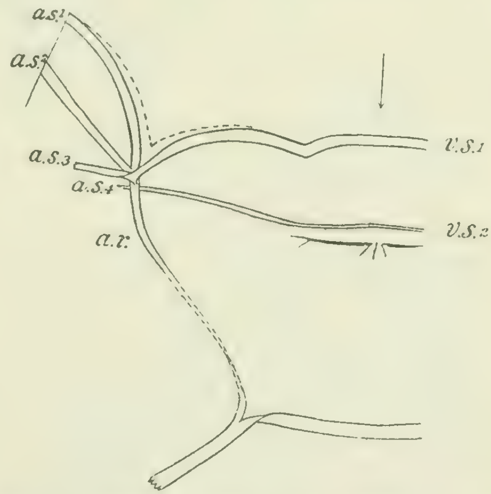

FIG. 122.—PEGEA CONFEDERATA, ADULT SOLITARY FORM ATRIAL MUSCULATURE OF THE LEFT HALF OF THE BODY, FROM A PREPARATION SIMILAR TO THAT FROM WHICH TEXT FIGURE 122 WAS DRAWN. × 12 DIAMETERS.

The muscles of the aggregated *Pegea confederata* (fig. 123) show a closer resemblance to those of the solitary form than is the case in any other species of Salpidae. There are four body muscles, in two groups, on the dorsal surface, often hardly reaching to the sides of the body. The intermediate muscle and the oral musculature (fig. 124) are as in the solitary form, except for minor details which comparison of the figures will show.

The atrial musculature in my very numerous specimens is as shown in figure 125. There is a well-developed atrial retractor giving rise above to the broad third dorsal sphincter muscle, which, by the way, is interrupted on each side. There is a delicate admarginal dorsal sphincter, also interrupted on each side, and a second dorsal sphincter, which is very incomplete, being represented only by a short branch on each side. The first and second dorsal sphincters are united below into a broad band which lies external to the third dorsal sphincter and atrial retractor. The admarginal ventral sphincter arises by two roots, one from the posterior edge of the third dorsal sphincter, at its junction with the atrial retractor, the other from the ventral edge of the common portion of the first and second dorsal sphincters. These two roots soon unite to form the single admarginal ventral sphincter. A second ventral sphincter muscle (*v. s. 2*) corresponds to the basal atrial sphincter of other species, only its ventral half being present in *Pegea* (see fig. 3, pl. 1, of *Cyclosalpa pinnata*). It is connected with the fourth body muscle, as shown in the figure.

In front of this basal sphincter lies another, broader muscle which is morphologically the posterior branch of the fourth body muscle, though it is, in *Pegea*, actually distinct from the latter. It runs toward, but does not reach, the mid-ventral line of the base of the atrial siphon, its ventral end turning slightly forward toward the gut, suggesting the origin of the visceral muscle (v) in other forms (see fig. 3, pl. 1, *Cyclosalpa pinnata*, and fig. 13, pl. 4, *Cyclosalpa floridana*).

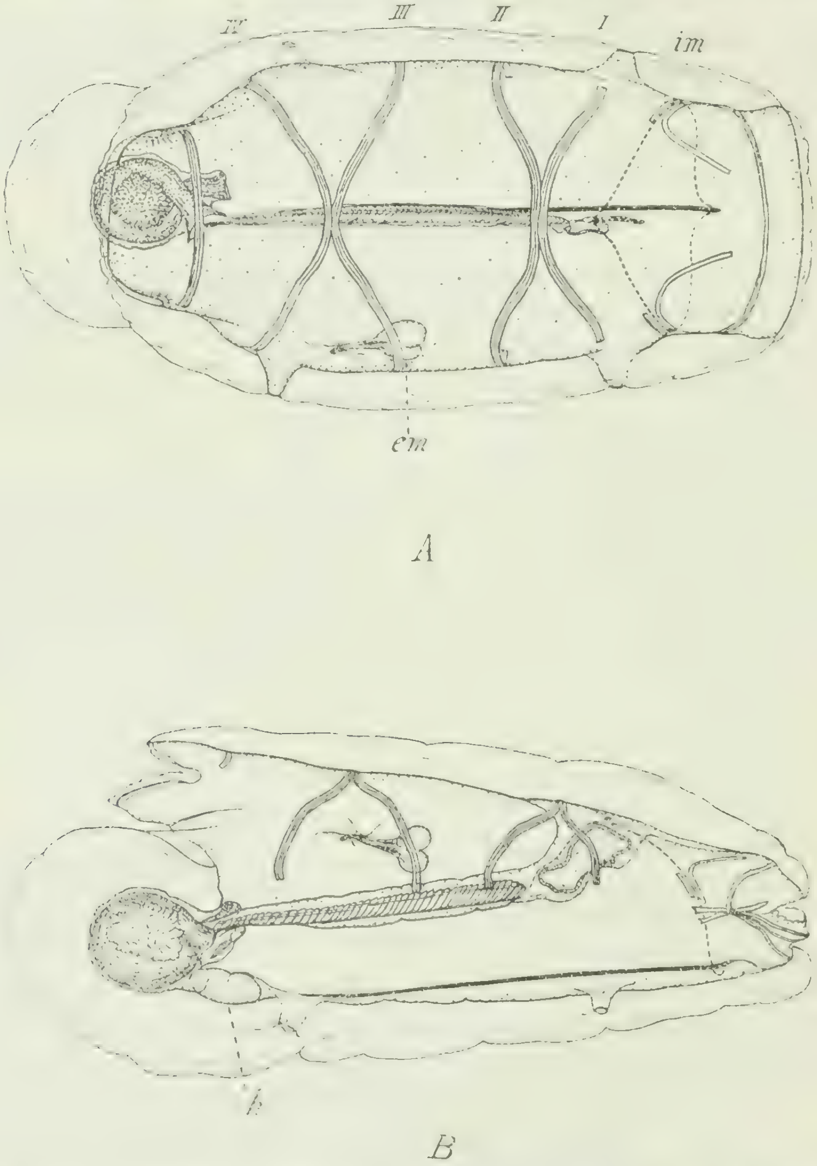

FIG. 123.—PEGEA CONFEDERATA, AGGREGATED ZOÖID: *A*, DORSAL VIEW; *B*, VIEW FROM RIGHT SIDE. × 1⅓ DIAMETERS. FROM SPECIMENS COLLECTED IN PHILIPPINE WATERS. (DRAWN BY HOYT S. HOPKINS.)

The gut in the aggregated zoöids is similar to that in the solitary form. It is more or less covered by the fine brown branches of the intestinal gland. In the loop of the gut lies the well-developed greenish yellow testis. Surrounding the viscera in the post abdomen is a large blood sinus from which vessels or lacunae pass into the visceral mass, usually between the testis and the gut. The open ends of these vessels in surface view look like perforations such as would be made by a dissecting needle.

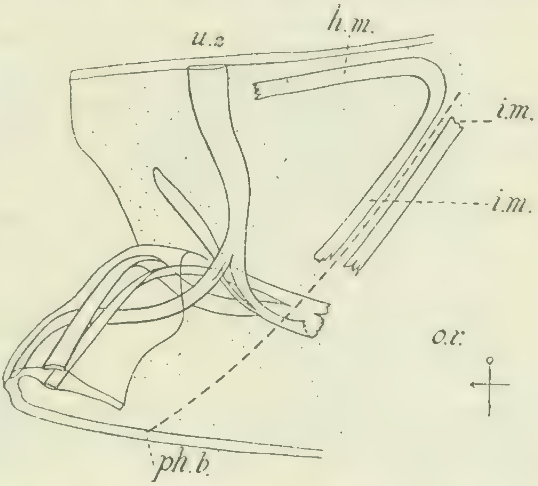

FIG. 124.—PEGEA CONFEDERATA, AGGREGATED FORM, ORAL MUSCULATURE OF THE RIGHT SIDE, SEEN FROM THE INSIDE. FROM SPECIMENS COLLECTED IN PHILIPPINE WATERS.

The neural gland shows the usual two disks, each with a convoluted duct. There are a pair of elongated, large-celled outgrowths from the ganglion, one on each side.

The eyes (figs. 126 and 127) are of interest. The large dorsal eye is in two parts, a posterior portion (e'') with the pigment below the rod-cells, and an anterior portion (e') with its pigment above the rod-cells. The optic nerve runs between the two, giving fibers to each portion.

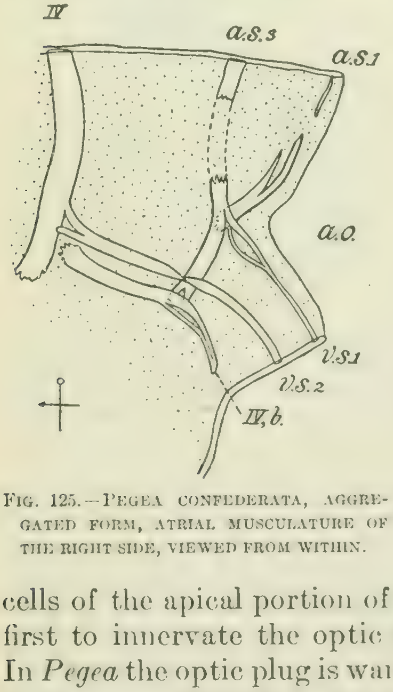

FIG. 125.—PEGEA CONFEDERATA, AGGREGATED FORM, ATRIAL MUSCULATURE OF THE RIGHT SIDE, VIEWED FROM WITHIN.

The rod-cells are irregular in shape with irregularly thickened walls; that is, they are degenerate.

Comparison with the eyes of any other subgenus except *Traustedtia,* say with those of *Cyclosalpa pinnata* (figs. 9, p. 23, and 12, p. 25), shows that in *Pegea* there has been no reversal of the dorsal eye such as has occurred in other Salpidæ. In *Cyclosalpa pinnata* the optic nerve leaves the ganglion, passes above the basal portions of the eye (e'), some of the fibers going on to the middle of the eye where they pass through the arch of the horseshoe to reach the rod-cells of the apical portion of the eye (e''), some fibers being given off first to innervate the optic plug (e''') (see Metcalf, 1893, c. pl. 48). In *Pegea* the optic plug is wanting. The crucial point is that the optic nerve passes directly to the rod-cells of the anterior portion of the eye, not up and over this part of the eye. In *Cyclosalpa* the basal portion of the eye (posterior limbs) has its pigment ventral and its rod-cells dorsal and the optic nerve passes up over the limbs of the eye to reach its dorsally lying rod-cells. In *Pegea* these relations are exactly reversed in the corresponding portions of the eye (*e*′). The pigment is dorsal and the nerve fibers reach the rod-cells directly from the ganglion.

Of course, if no inversion has occurred in the eye of this species, that portion of the eye (*e*′′), which in *Cyclosalpa* lies anterior to the basal portion, must in *Pegea* lie behind the basal division. These are the relations observed in *Pegea*. Posterior to that portion of the eye which we have labelled *e*′ lies a second division (*e*′′) whose rod-cells are dorsal and whose pigment is ventral. The optic nerve passes between the two portions of the eye to reach the rod-cells of the second portion (*e*′′). This lack of inversion of the dorsal eye in the aggregated zoöid of *Pegea* marks this subgenus off sharply from all the other subgenera except probably Traustedtia, which we will soon discuss.

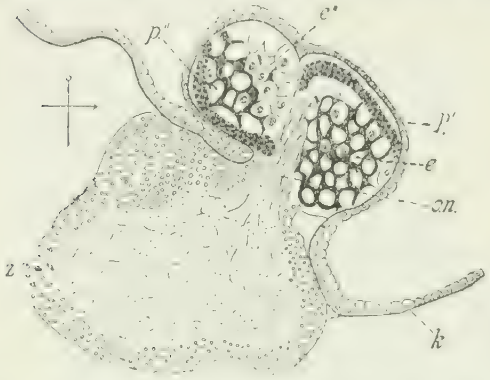

FIG. 126.—PEGEA CONFEDERATA, AGGREGATED FORM, SOMEWHAT OBLIQUE VERTICAL SECTION OF THE GANGLION AND DORSAL EYES. × 170 DIAMETERS. FROM METCALF (1893, c).

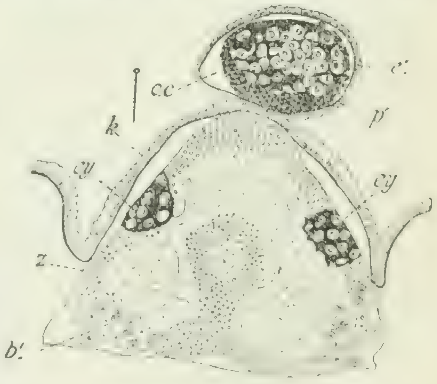

FIG. 127.—PEGEA CONFEDERATA, AGGREGATED FORM, CROSS SECTION OF DORSAL EYES AND OF GANGLION, SHOWING ALSO THE PAIR OF ACCESSORY EYES IN THE GANGLION. × 170 DIAMETERS. FROM METCALF (1893, c).

In the ganglion of *Pegea confederata* are two accessory eyes (fig. 127), which I have before described as follows (Metcalf, 1893, *c*):

> Two masses of similar, thick-walled cells are present in the ganglion, one on the right, the other on the left, a little above the midpoint, of the lateral faces of the ganglion. These cells exactly resemble the peculiar rod-cells of the large dorsal eye in size, shape, character of nuclei, thickness of cell walls, in manner of staining and in their general appearance. The arrangement of chromatin in their nuclei and in the nuclei of the rod-cells of the dorsal eye is very different from that seen in the other cells of similar size found in the periphery of the ganglion. In the former, the nuclei contain many small chromatin granules, and no very large nucleolus. The other cells of the ganglion are of two sorts, the one sort small, with small nuclei. These are utterly different from the cells we are discussing. The other kind of ganglion cells is larger, about equal in size to the rod-cells of the eye. They have the same sized nuclei, but in these the chromatin is nearly all collected into a large nucleolus, giving a decidedly different appearance from the nuclei of the rod-cells. Besides this their

protoplasm reacts much more strongly with hæmatoxylin, giving a deep stain, while the protoplasm of the rod-cells stains very weakly. These characters, and especially the great thickness of their cell walls, distinguish the rod-cells of the eye, and of the two lateral masses in the ganglion, from any others of the nerve cells. We must, then, regard these two lateral masses of rod-like cells that are found in the ganglion as imperfect or degenerate eyes, bearing the same relation to the larger eye of this species as the smaller dorsal eyes of the chain *Cyclosalpa pinnata* do to the large, unpaired eye of that species. These structures just described form a connecting link between the smaller eyes found in *Cyclosalpa pinnata* [see fig. 9, p. 23] and *Salpa cylindrica* [see figs. 87, p. 98, and 89], which are undoubted optic organs, and other structures found in *Salpa hexagona* [see figs. 45, p. 70, and 47], *Salpa costata-tilesii* [see fig. 118, p. 126], and *Salpa cordiformis-zonaria* [see fig. 103, p. 108], which are so different from the typical eye that one would not readily recognize their true character.

OCCURRENCE OF PEGEA CONFEDERATA.

The aggregated form of *Pegea confederata* is one of the most abundant of the Salpa group. In the collections made by the United States Bureau of Fisheries steamer *Albatross* in the Philippine waters, it was the most abundant of all the Salpas, and in the United States National Museum collections made since 1875 it is very abundant. In all these collections there are, on the other hand, very few representatives of the solitary form of this species except numerous embryos from 5 mm. to 35 mm. long. There are five individuals, one 38 mm. long, two 40 mm. long, and two 42 mm. long, in which the eleoblast is absorbed. All the other specimens of the solitary form, even the few which are of large size (2–3½ cm. in length), show the eleoblast large and prominent and are evidently embryos recently set free. The larger individuals mentioned above may well be called adult, for all five of them show stolons, two of these showing the aggregated zoöids 1½ mm. in length. These five solitary individuals were collected at the surface by the steamer *Albatross*, one in July at station 4037, Hawaiian Islands, three from Philippine waters in February and in September, and one from station 1098, off the coast of New England.

This scarcity of the solitary form of *Pegea confederata* is a general condition in collections of Salpidæ.

The *Challenger* Expedition (Herdman, 1888) found five aggregated zoöids of the form *bicaudata* in one haul in Philippine waters, and no solitary specimens. They also found, in the south Pacific, the test of one large individual so degenerate that it was impossible to distinguish whether it belonged to a solitary or an aggregated individual.

The Plankton Expedition (Apstein, 1894, *b*) found, in the West Indies and the Gulf Stream, in the late summer and fall, 793 individuals of *Pegea confederata*, of which 437 were aggregated zoöids and 356 were solitary forms including embryos. No indication is given in Apstein's report of the number of adult solitary individuals, if any such were present.

Apstein's report (1906, *a*) of the occurrence of *Pegea confederata* in the Südpolar collections may best be shown in tabular form:

Number of hauls.	Month.	Depth in meters.	Number of solitary form, including embryos.	Number of aggregated form.
6	August	0	2	1,022
1	do	0	(1)	(1)
1	September	20	2	10
1	do	0	1	0
2	do	10	9	12
1	November	0	0	6
1	April	(?)	3	6
1	May	20	1	24
2	do	0	1	4
Total			19+	1,084+

[1] Number and forms not stated.

Apstein reports from the Tiefsee Expedition (1906, *b*) the occurrence of *Pegea* as follows:

Station.	Depth in meters.	Number of solitary form, including embryos.	Number of aggregated form.
172	0	0	2
173	0	0	1
	0–2500	0	100
	30	0	(1)
182	0–2400	0	2
200	30	0	(1)
201	0	0	4
236	0–2000	0	(1)
237	0–2000	0	(1)
238	0–3000	0	1
250	0	2	0
258	0	4	0
261	0	1	107
262	0	0	35
263	(?)	5	(1)
	0–830	0	1
Total		12	256+5

[1] Number not stated.

Ihle reports (1910), from the *Siboga* Expedition, that the aggregated form of *Pegea confederata* was found at five stations, twice in great numbers, and that one specimen of the solitary form, 43 mm. long, was found at another station.

Ritter says, in his Pelagic Tunicata, of the San Diego region:

> The aggregate generation is not rare in the area, but not a single zoöid of the solitary generation has thus far been observed. The species has been taken on the California coast from Monterey Bay southward, and in the months of January, February, March, May, June, July, and August.

Under date of March 10, Professor Ritter writes me:

> Curiously enough, although the aggregated form of this species is one of the most abundant in this region, I have seen only two specimens of the solitary form.

In a later letter, referring to his paper on the Pelagic Tunicata of the San Diego region, he writes:

> At the time I had seen but one specimen of the form. Since then the number has been increased to two by the handling of thousands of specimens.

It will be seen, therefore, how abundant the aggregated form of this species is, and how rare are full grown adults in collections thus far made. What may be the explanation of this condition? *Thalia democratica*, the most abundant and the most widely distributed of the Salpidae, shows conditions of vertical distribution that are suggestive in this connection. The solitary individuals lie at considerable depth during winter, spring, and early summer, coming to the surface with the aggregated zoöids in the fall. It seems not unlikely that the solitary *Pegea confederata* lies generally in deep water the year round, a few wholly adult individuals coming to the surface only occasionally, the great majority probably never coming to the surface except more or less by accident. The Plankton Expedition reports 51 solitary individuals (including embryos) collected in four hauls of the vertical net. These may have been lying at any depth. In the Süd-polar Expedition collections, three solitary individuals are reported from the surface, nine from a depth of 10 meters, three from a depth of 20 meters, and three from an unknown depth. How many of these were embryos was not stated. The Tiefsee Expedition reports seven of the solitary form from the surface and five from unknown depths. In this case again it is not stated whether the individuals were fully formed adults or embryos. More data as to the vertical distribution of *Pegea* are much to be desired. Such data as we have support the suggestion that the solitary individuals seldom reach the surface, but may be much more abundant at some depth.

PEGEA CONFEDERATA, subspecies BICAUDATA (Quoy and Gaimard, 1826).

S. nephodea LESSON, 1830.
Salpa bicaudata QUOY AND GAIMARD, 1826.

The solitary form of this salp has not been clearly distinguished. In fact, most recent authors deny to *bicaudata* any consideration even as a distinct variety. The aggregated zoöids of the *Pegea* which Streiff studied and described as *P. confederata* belonged to the form *bicaudata*, and the presumption is that the solitary individuals were of the same subspecies to which the aggregated zoöids belonged, but of course this is not certain. His specimens of the solitary form were very different from mine, in the character of their atrial musculature, and were somewhat different in the character of the oral musculature. His specimens of the aggregated zoöids were clearly of the *bicaudata* character, as is shown by his "Fig. 25, Taf. 3" (my fig. 131, page 142), and they show considerable divergence from my specimens in oral and atrial muscles.

PEGEA CONFEDERATA, subspecies BICAUDATA, solitary form.

I have had two specimens which may be of this form. One is 5 mm. long. This was given me long ago by Prof. W. K. Brooks. Its source I do not know, nor do I know the authority for the label *bicaudata*. The other embryo is 25 mm. long, but shows the eleoblast still large. Both of these embryos agree in oral musculature with Streiff's figures (*bicaudata*?), but not in atrial musculature, in which they agree with *confederata*. Assuming that Streiff's specimens, though described as *P. confederata*, were really specimens of the subspecies *bicaudata*, I am copying his figures, giving merely enough description to call attention to the differences from *Pegea confederata*.

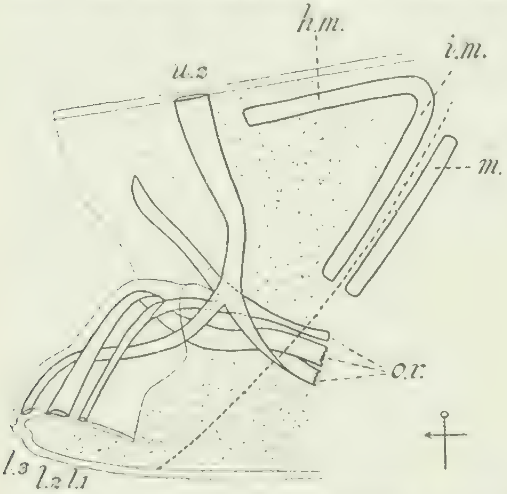

Fig. 128.—Pegea confederata, subspecies bicaudata, oral muscles of either solitary or aggregated form, seen from within. From Streiff (1908).

Streiff describes the body muscles as agreeing exactly with those he describes and figures for the aggregated zoöids (fig. 130, p. 142). Their condition agrees also with what I find in the body muscles of *Pegea confederata*.

The intermediate muscle (fig. 128) is as in my specimens of *Pegea confederata* (fig. 120, p. 132), except that both its divisions are shorter ventrally, ending some distance above the oral retractor muscles.

Streiff says the oral musculature agrees exactly with that he describes for the aggregated zoöid (fig. 128). The divergence from my specimens of the solitary *Pegea confederata* is slight but is noticeable (fig. 120, p. 132). The oral retractor of *bicaudata* instead of being divided into two, a dorsal retractor and a ventral retractor, is divided into three horizontal bands, as in *Thalia* (fig. 105, p. 112). The oral sphincters connected with them are as in my specimens of *Pegea confederata*.

The atrial musculature described and figured by Streiff (fig. 129) is decidedly different from what I find in all of my specimens. I will not attempt even to indicate the homologies between the muscles in the two forms, except in the case of the atrial retractor and the fourth body muscle, which I label in his figure, to aid in orienting it in comparison with my figure 122. The differences here would seem almost to deserve emphasis as of specific value. It seems probable that Streiff's specimens were *bicaudata* and that both of my possible *bicaudata* embryos are really *confederata*, though one bears the label *bicaudata* and the other is in a phial with two aggregated *bicaudata* and one aggregated *confederata*. The solitary form of *bicaudata* needs further study.

PEGEA CONFEDERATA, subspecies BICAUDATA, aggregated form.

I have had nine lots of alcoholic specimens of the aggregated zoöids of this subspecies, collected by the United States Bureau of Fisheries steamer *Albatross*, off the eastern coast of the United States between Cape Hatteras and Cape Cod, also three specimens from the Naples Zoological Station (U. S. National Museum, Cat. No. 6462). They show the appendages, and the eyes are of the bicaudata type. Their musculature also agrees with Streiff's description. The description here given is based chiefly on Streiff's results, confirmed, however, from my material.

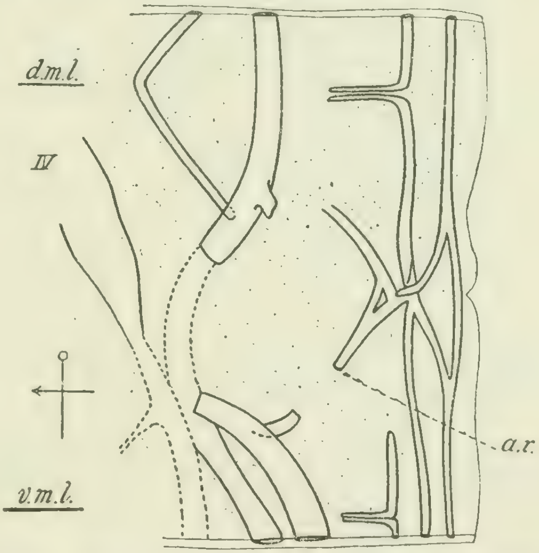

FIG. 129.—PEGEA CONFEDERATA, SUBSPECIES BICAUDATA, SOLITARY FORM, CLOACAL MUSCLES: *d. m. l.*, DORSAL MID LINE; *v. m. l.*, VENTRAL MID LINE. FROM STREIFF (1908).

The aggregated zoöid (fig. 130) is very similar to that of the typical *Pegea confederata* but can be distinguished by several features: first, by the presence of a pair of long postero-lateral tubular appendages; second, by slight features in the character of the muscles of the oral region; third by more marked divergences from the species proper in its atrial musculature; and fourth, by the stalked character of its large dorsal eye.

The body muscles are as in the aggregated *Pegea confederata* proper. The intermediate muscle (fig. 128) is "as in the solitary" *bicaudata* and the aggregated *confederata* (fig. 124), differing from that of the solitary *confederata* (fig. 120) in being shorter, ending some distance above the oral retractor. The dorsal horizontal band with which it is continuous dorsally is as in the aggregated *confederata*, being longer than in the solitary *confederata*, reaching more nearly to the broad sphincter muscle of the upper lip. The oral muscles proper differ from those of the aggregated *confederata* only in the divisions of the oral retractor and in the position of the first sphincter of the ventral lip, which is just below the second sphincter in contact with the epithelium of its inner surface. The atrial muscles (fig. 131) differ more from those of the aggregated *confederata* (fig. 125). Each muscle in one is present in the other, but their conditions and connections are different.

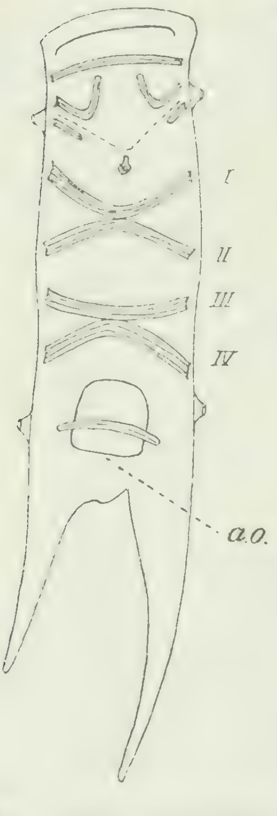

FIG. 130.—PEGEA CONFEDERATA, SUBSPECIES BICAUDATA, AGGREGATED ZOÖID, DORSAL VIEW. FROM STREIFF (1908).

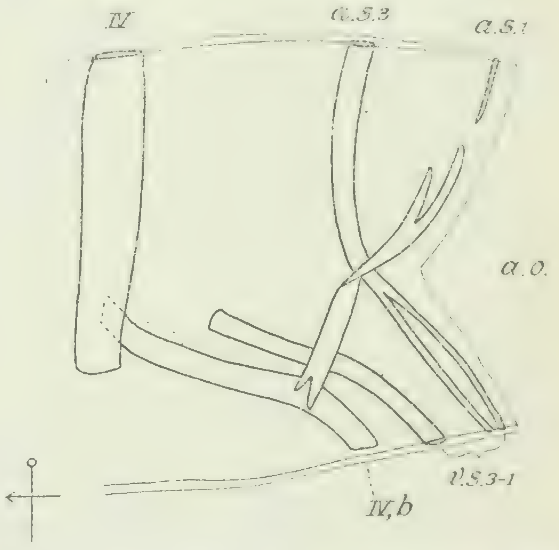

FIG. 131.—PEGEA CONFEDERATA, SUBSPECIES BICAUDATA, AGGREGATED FORM, ATRIAL MUSCULATURE VIEWED FROM THE LEFT SIDE. FROM STREIFF (1908).

The dorsal eye (fig. 132) differs from that of *confederata* (fig. 126) only in being raised on a stalk of considerable length, formed by the optic nerve, whose fibers in both *bicaudata* and *confederata* enter the eye between its two divisions.

The accessory eyes in the ganglion are similar in the species and in the subspecies.

With any strictly scientific definition of species, and species among the Salpidae are clearly demarcated and real, one would have to recognize *bicaudata* as a true species, but the resemblance to *confederata* is so close that it is probably preferable to rank *bicaudata* as a subspecies of *confederata*. This classification emphasizes the evident close relationship between the two forms.

Pegea is a highly modified subgenus. It is noteworthy that the solitary form, which in most species is in all respects more conservative than the aggregated zoöid, has, in this species, diverged from the ancient character almost as much as the aggregated zoöids.

This is seen in the muscles, which are equally reduced in the two phases of the life history. The gut also is in the same condition in the two.

In both forms of *Pegea*, as in *Thetys vagina* and *Iasis zonaria*, all the rod-cells in all the eyes of the aggregated zoöids are irregular and degenerate.

Traustedtia, new subgenus.

This subgenus includes the most highly modified members of the family. It has been studied by Quoy and Gaimard (1826–1834), Traustedt (1893), Apstein (1894, *b*, 1904, 1906, *b*) and Dober (1912). Ihle (1911) discusses briefly the nomenclature. In Apstein's several accounts two species seem to be confused. Our specimen aids little in clearing up this confusion. All the material previously known should be restudied. The Traustedtias are rare forms and new material is not likely often to be found or to be abundant when found. Assuming the general accuracy of the descriptions that have been published, I am tentatively recognizing two species—*multitentaculata* and *radiata*. We have had only a single specimen of the solitary form of the species *multitentaculata*. This will first be described. It is different enough from Apstein's specimen to be placed in a distinct subspecies. The species *multitentaculata* may be taken as the type of the subgenus since it was the first described and its aggregated form is known.

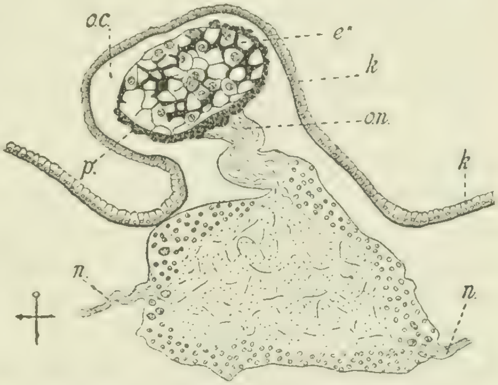

Fig. 132.—Pegea confederata, subspecies bicaudata, aggregated form, oblique vertical section of the ganglion, optic nerve and one half of the dorsal eye. × 180 diameters. From Metcalf (1893, c).

TRAUSTEDTIA MULTITENTACULATA, new subspecies BICRISTATA, solitary form.

Plate 14.

The United States National Museum collections contain a single example of the solitary form of this very rare salpa. Cat. No. 6430 (Type) U.S.N.M.; (solitary form), *Albatross* station D. 2585, off Marthas Vineyard; September 19, 1885; 542 fathoms; surface temperature, 73° F. It was collected at the surface of the ocean, along with very many solitary and aggregated zoöids of *Thalia democratica*, among which we found it, in a large bottle containing several thousand *Thalias*. The specimen, 7.5 mm. long, is in perfect condition, being excellently preserved in picric acid and alcohol. We have had no specimens of the aggregated zoöids, nor is the stolon in our specimen sufficiently developed to tell anything of their character.

Of all described Salpas, the solitary form of the crested subspecies of *Traustedtia multitentaculata* is by far the strangest and most bizarre in form. A complete verbal description is useless. The figures need, however, some description, if the peculiar crests and protuberances from the surface of the test are to be clearly understood.

The body is, in general, elongated ovoid, 7½ mm. long, the posterior end a little broader and considerably deeper than the anterior end. The test is much thickened below and considerably thickened on the sides of the body, but along the mid-dorsal line is a rather narrow area of thinner test. On each side of this thinner mid-dorsal strip the thickened test of the sides rises up into a huge longitudinal crest with a coarsely toothed dorsal margin. These structures may be called the dorso-lateral crests. The anterior edges of the crests are continuous below with the anterior edges of the thickened lateral areas of test. Similarly the posterior edges of the dorso-lateral crests are continuous below with the posterior and dorsal edges of the lateral and ventral area of thickened test. It is as if an envelope of greatly thickened test were laid under the ventral surafce of the body and bent up around the sides, its upper edges not meeting on the dorsal surface but being elevated into two independent dorso-lateral crests, the anterior end of the body and the atrial siphon, covered only with thin test, protruding in front and postero-dorsally from the thickened envelope.

The test over the lower lip is somewhat thickened and is coarsely and irregularly papillate, the individual papillae resembling the irregular teeth upon the edges of the dorso-lateral crests. The mid-dorsal line of the upper lip bears a row of similar irregular papillae; so also do the mid-dorsal and the mid-ventral lines of the atrial siphon. Over the sides of the body, especially along the mid-lateral region, are similar papillae.

The great ventral thickening of the test is even more strongly emphasized posteriorly, where it forms a great pouch containing the viscera. This postero-ventral thickening is broad from side to side, its postero-dorsal edge showing two strongly toothed ridges running from side to side. The lower is the smaller of the two; the upper forms a sort of transverse crest behind and below the atrial siphon. Observation of the figures should, with this description, make the form clear.

As noticeable as the crests and ridges are the 13 "tentacles." These are of essentially the same character as the postero-lateral tubular protuberances in *Thalia* (fig. 104, p. 111) and *Thetys* (fig. 114, p. 122). Their positions are shown in the figures: a ventro-lateral pair in front (1); two lateral pairs, one below the anterior group of body muscles (2), and another below the anterior one of the posterior group of muscles (3); a pair in the posterior edges of the dorso-lateral crests (4); a pair at the sides of the atrial siphon (5); a posterior pair near the mid line, ventral to the horizontal crest below the atrial siphon (6); and a single median posterior one (7) which does not actually protrude beyond the contour of the crests but lies in the lesser posterior ridge at the posterior end of the body. Each of these "tentacles" contains a tube of mantle epithelium, which at its tip is slightly enlarged.

The muscles are confined to the dorsal half of the body. They are but slightly developed. The intermediate muscle functions in connection with the oral muscles, as in *Thetys* and *Pegea*, and will be described in connection with these muscles. There are four, or perhaps five, muscles which should be accounted body muscles. The anterior three of these are united across the dorsal line into a single band, the group much resembling the anterior group in *Thalia democratica* (fig. 104, p. 111), although the latter merely touch without fusing. Body muscle IV is longer and stretches farther down on the side of the body, bending forward at its lower end. Body muscle IV is branched, its narrower posterior branch running on each side to the base of the atrial siphon where it again branches into two, the upper of which gives off a minute branch which runs up to connect with the delicate atrial sphincter, while its larger portion passes below the atrial siphon to fuse with its fellow from the other side. The more ventral of the two branches formed by the second dichotomy of muscle IV turns downward and forward toward the visceral mass, which however it does not reach.

This arrangement of the branches of the fourth body muscle reminds one of the conditions in the aggregated zoöids of different species of *Cyclosalpa*, in which a posterior branch of the last body muscle passes beneath the atrial siphon, giving rise there to what we have described as the "visceral muscle," which in some cases is double (*Cyclosalpa affinis*, *C. floridana*) and in other cases is single (*C. bakeri*, *C. pinnata*, *C. virgula*). Even in *C. affinis* and *C. floridana* the visceral muscle is double only at its base, at its distal end the right and left halves being fused into one. But observe that the above comparison is between the solitary form in *Traustedtia* and the aggregated zoöids in the Cyclosalpas. In the very highly modified subgenus *Traustedtia*, the solitary form shows a feature which, in the more archaic Cyclosalpas, appears only in the aggregated zoöids. Even the conservative member of the life cycle, the solitary form, has in this divergent subgenus become much modified. Another modification of the solitary form is seen in *Traustedtia* and in *Pegea* in the reduction of the number of the body muscles.

At the base of the atrial siphon is another muscle nearly as well developed as body muscle IV and seeming to belong to the body-muscle series, but its position at the base of the siphon, and the fact that body muscle IV in its branching resembles the last body muscle of the aggregated zoöids of numerous species, suggest that the muscle in question may better be interpreted as a basal atrial muscle. Compare the conditions in the *Cyclosalpas*, both solitary and aggregated forms. Without insisting upon its homologies I label it in the figures as body muscle V.[1] This muscle is branched, a small band arising from its upper portion, on each side, and running back to unite with the delicate sphincter of the atrial siphon near its point of union with the very delicate uppermost branch of the posterior division of body muscle IV.

Between body muscles IV and V there is a minute oblique muscle on each side of the dorsal mid line not attached at either end to any other muscle.

There are two atrial sphincter muscles, an admarginal one and a very delicate submarginal one, which, on each side, is fused for a very short distance with the admarginal muscle. There is a short portion of a third sphincter across the ventral surface of the siphon below, anterior to, the delicate sphincter. The axial tube of the lateral "tentacle" (5) of the atrial siphon arises from the mantle exactly at the level of the admarginal atrial sphincter muscle (fig. 35), but there is no continuation of the muscle into the "tentacle" as the figures seem to indicate.

The oral musculature, like that in *Pegea*, is weakly developed. The intermediate muscle is present as a short band running obliquely internal to the two oral retractors. The two oral retractor muscles are horizontal or nearly so. The more ventral divides into two short branches which form abortive sphincter muscles, one at the base of the upper lip and the other at the base of the lower lip. The dorsal oral retractor muscle divides into three branches the upper of which forms a similar abortive first sphincter of the upper lip, while the more ventral two form the narrower and the wider complete sphincters of the incurved lower lip. There are no dorsal horizontal bands between the oral and body muscles.

The gut is in the form of a vertically placed elongated loop, much more compact than in *Cyclosalpa affinis* (pl. 3, fig. 10), less compact than in *Thalia* (fig. 104, p. 111).

The stolon is curved around the base of the intestinal loop, making about two-thirds of a circle, the two ends, however, being at widely different levels, thus forming a partial spiral.

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[1] The distinction between posterior body muscles and basal atrial muscles is doubtless not a fundamental one. The conditions, especially in *Traustedtia* and *Pegea*, seem to indicate that they are all serially homologous. The same muscle which in one species is developed as a body muscle may, in another species, serve as a basal atrial muscle.

The eye shows the usual horseshoe shape. Its histology has not been studied, since we were unwilling to sacrifice our sole specimen of the subspecies. For the same reason the neural glands and the outgrowths from the ganglion have not been observed.

TRAUSTEDTIA MULTITENTACULATA (Quoy and Gaimard, 1826-1834).

Salpa multitentaculata Quoy and Gaimard, 1826–1834.
S. verrucosa Apstein, 1894, *b*.
S. multitentaculata Ihle, 1911, in part.

SOLITARY FORM.

In his report upon the Thaliacea of the Plankton Expedition, Apstein (1894, *b*) describes a single specimen (fig. 133) which he took to be an aggregated zoöid, but which proves to be a solitary salpa.

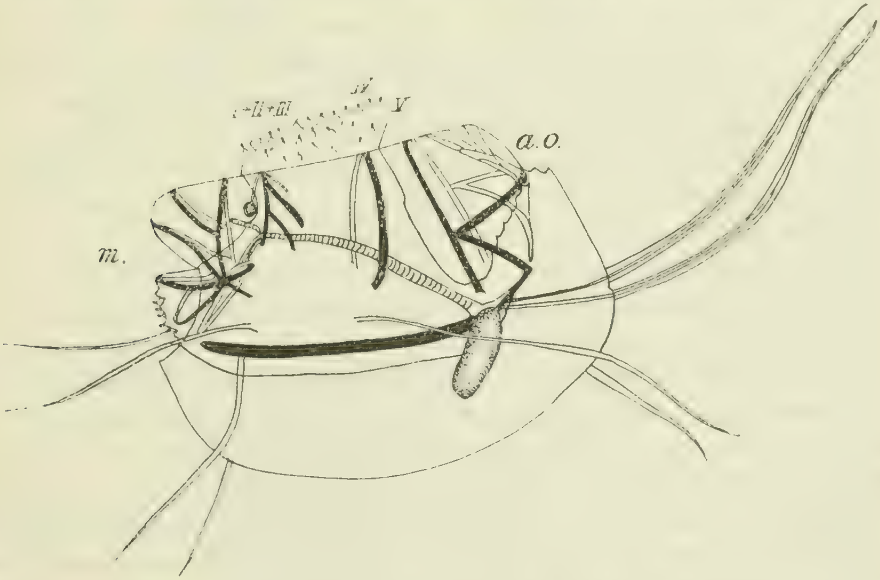

Fig. 133.—Transtedtia multitentaculata, solitary form, viewed from the left side. × diameters. From Apstein (1894, *b*).

It differs markedly from our specimen but still seems to belong to the same species. He describes a single dorsal crest, but his only specimen was strongly laterally compressed, so the two crests, if present, may have appeared as one. The test was greatly thickened ventrally and his figure shows lines connecting the anterior and posterior edges of the crest with the thickened area of ventral test, just as we have shown them for our specimen. The form of the body is evidently quite similar in Apstein's specimen and ours. Apstein describes and figures four pairs of "tentacles" corresponding to the larger four pairs in our specimen. He does not describe the other five similar but less developed structures which we show in our form. He may have overlooked them, for they are not prominent.

The mass of the gut is of the same form and has a similar position in the two specimens.

One would without hesitation assign both specimens to the same species were it not for the different condition of the muscles. Body muscles I, II, and III (our notation) are very similar in the two specimens. Body muscle IV is unbranched in Apstein's specimen and branched in ours. The muscle next posterior is very different in the two specimens. The discrepancy would, however, be removed if we were to add to Apstein's figure a posterior branch of body muscle IV extending across the next posterior muscle and itself giving rise to the two oblique bands which Apstein figures between the gut and the atrial siphon. This would leave the fifth muscle unbranched below, as in our specimen, and it should then possibly be considered the basal muscle of the atrial siphon, as comparison with the *Cyclosalpas* suggests. Comparison of Dober's (1912) and Apstein's (1906, *a*) figures of *Traustedtia radiata* (figs. 138 and 139) shows that the posterior branches of body muscle IV may be interrupted in some specimens and complete in others. In similar cases in other species, the potential position of an omitted or interrupted muscle is indicated by the presence of a muscle blood vessel along the course the muscle would take if present.

There is such disagreement in the oral and intermediate muscles as Apstein and we describe them as to necessitate treating his specimen and ours as representing distinct subspecies. The intermediate muscle (Apstein's first body muscle) is described and figured as complete across the dorsal mid line, being continuous with its fellow of the other side. In our specimens it extends but a little way above the angle of the mouth. Apstein says there is one sphincter muscle in each lip, but he figures two in each, all four complete from the angle of the mouth on one side, across the mid line, to the angle of the mouth on the other side.

In our specimens the two sphincters of the ventral lip are complete, but the two in the dorsal lip are very rudimentary, extending but a very short distance above the angle of the mouth. The distinctive features of Apstein's form, as compared with our specimen, are, first, the smaller number and greater length of the "tentacles," and the complete and conspicuous muscles crossing the dorsal surface of the anterior end of the body, that is, the first and second sphincters of the upper lip and the intermediate muscle, very different from the vestigial corresponding muscles in our specimen. These two subspecies, though apparently distinct, are very similar, as much alike as are the solitary forms of *Salpa maxima* and *S. fusiformis*, not so closely similar as *S. fusiformis* and its form *aspera*, which differ only in the character of the test.

Quoy and Gaimard's *Salpa multitentaculata* (fig. 134) seems to be the same as Apstein's *S. verrucosa*, though their figure and description are not sufficiently complete to make one entirely certain. Yet the general form of the body and the position of the four pairs of "tentacles" seem to indicate probable identity. Quoy and Gaimard's description and figure are given for comparison. Quoy and Gaimard's form seems clearly a *Transtedtia*, and of the probably two species now known it must belong to *multitentaculata*. It is either this species or one not as yet rediscovered. The elongation of the posterior "tentacles" in Quoy and Gaimard's and Apstein's specimens is greater than in our form. I therefore assign Apstein's specimen to the main species and our specimen to the subspecies.

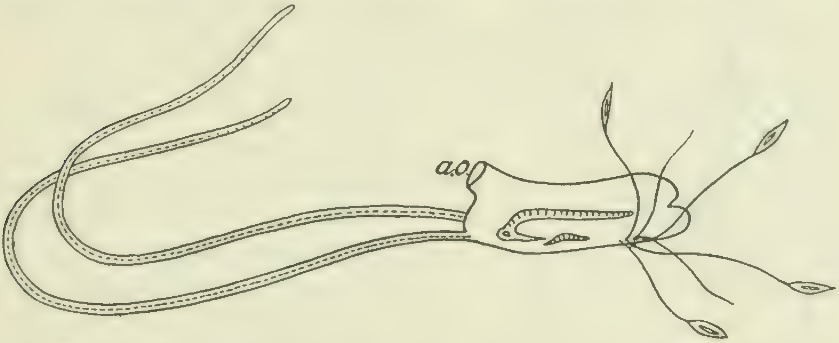

FIG. 134.—TRANSTEDTIA MULTITENTACULATA. QUOY AND GAIMARD (1826–1834).

Quoy and Gaimard's description is as follows:

15. BIPHORE MULTITENTACULÉ. SALPA MULTITENTACULATA, NOB.

Planche 89, figure 19.

Salpa, parva, cylindrica, postice longissime bicaudata, antice capillata; appendicibus gracilibus ápice tuberculosis; oribus terminalibus.

Cette espèce est une des plus singulières que nous ayons rencontrées, par les filaments qu'elle porte en avant. Elle est cylindrique, obtuse aux deux extrémités. L'antérieure, arrondie, a son ouverture terminale entre deux lèveres épaisses; la postérieure, un peu gibbeuse, a églament son ouverture presqu'à la pointe portée sur un petit prolongement. De la gibbosité partent deux très-longs filaments déliés, marqués d'une ligne rouge dans toute leur étendue. Au-dessus de la partie antérieure sont fixes six appendices filamenteux, renflés, pointus àleur extrémité, qui est rouge. Ils sont presqu'aussi longs que le corps. Le nucléus est orangé; le reste de l'animal, blanc. Au-dessus des organes digestifs on aperçoit un petit corps contourné, qui est sans doute une chaîne d'œufs.

Dimensions.

	Pouces.
Longueur du corps environ	1
Longueur des filaments postérieurs	3 ou 4

Habite les mers de la Nouvelle-Irlande.

TRAUSTEDTIA MULTITENTACULATA, aggregated form.

Traustedt (1893) first described the aggregated form of this species from specimens in the collections of the Plankton Expedition, from the

Atlantic Ocean off Rio Janeiro. He does not indicate the number of specimens he had. The individuals were 20 mm. long.

Apstein (1894, *b* and 1904) describes well-developed zoöids, 1.5 mm. and 3 mm. long, still attached to the stolon of the parent, so that the connection between the solitary and aggregated forms is established. He reports (1906, *b*) numerous specimens from the collections of the Tiefsee Expedition, agreeing exactly with those from the Plankton Expedition. Dober (1912) figures an individual from the Tiefsee collections which is clearly the same as Traustedt's original form. Traustedt and Dober both figure the ganglion and eye as seen in surface view. Our knowledge of the aggregated zoöid of the species *multitentaculata* is thus considerable, though not complete as to the oral and atrial musculature.

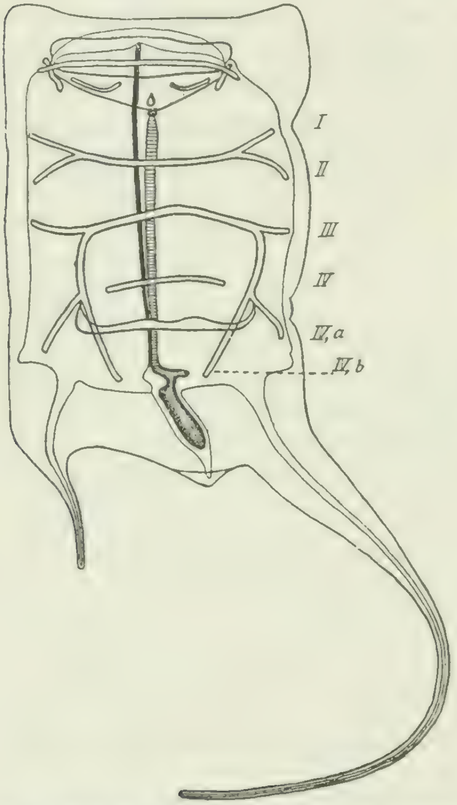

FIG. 135.—TRANSTEDTIA MULTITENTACULATA, AGGREGATED ZOÖID, DORSAL VIEW. × 4⅔ DIAMETERS. FROM DOBER (1912).

Dober's figure is here copied (fig. 135) and also Apstein's (1904) side view of a much younger individual (fig. 136). The index letters and figures are mine and show the homologies with other species. I would call attention to the fact that there are but two well developed body muscles. The first of these is evidently double. The second is branched in the same way as is body muscle IV in the solitary forms of this species and *Traustedtia multitentaculata*, form *bicristata*. We seem, therefore, to have four body muscles in the solitary form and three in the aggregated zoöids. The next posterior muscle corresponds to the one which in the solitary individuals we interpreted as either a fifth body muscle or a basal atrial sphincter.

Neither Dober's nor Apstein's figure shows other atrial muscles clearly enough for us to discuss them.

Apstein shows a well developed intermediate muscle complete across the dorsal surface. Dober shows what appears to be a double intermediate muscle, the posterior portion reduced to a vestige at the angle of the mouth, the anterior portion lying more dorsal and bending forward at its upper end to form what appears to be the homolog of the dorsal horizontal band of other species.

Apstein shows an oral retractor continued in front to form a single complete sphincter in each lip. Dober shows an oral retractor continuous with a complete sphincter in one lip (dorsal or ventral?), but no sphincter in the other lip.

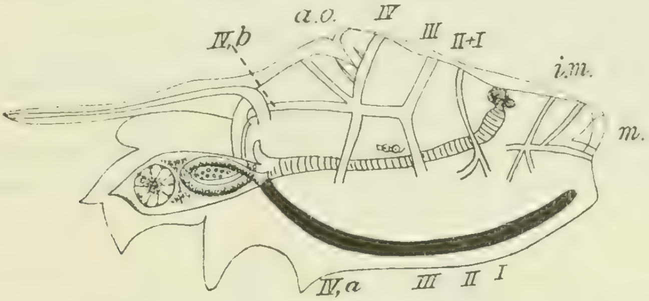

FIG. 136.—TRANSTEDTIA MULTITENTACULATA, AGGREGATED ZOÖID, VIEWED FROM THE RIGHT SIDE. × 2 DIAMETERS. FROM APSTEIN (1904).

Two embryos are said by Apstein to be borne by the aggregated zoöids in all cases; Traustedt observed but one, this very young.

Traustedt describes the ganglion and eye, and Dober gives a still clearer figure which is here copied (fig. 137). The eye apparently is very similar to that of *Pegea*, the homologies of whose parts I have already discussed.

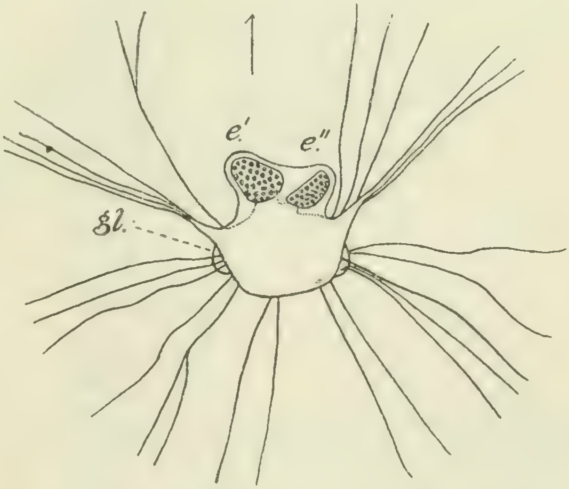

FIG. 137.—TRANSTEDTIA MULTITENTACULATA, AGGREGATED FORM, DORSAL VIEW OF THE GANGLION AND EYE. THE DISKS OF THE SUBNEURAL GLAND ALSO SHOW IN PART. FROM DOBER (1912).

Beneath the ganglion are a pair of lateral disks forming the subneural gland. Dober does not describe their ducts, but these are doubtless present. Dober refers to the disks as auditory organs. Of course there is no ground for attributing any such function to them (*see* Metcalf, 1893, *c*).

All the aggregated Traustedtias hitherto described seem to belong to the species *multitentaculata.* Quite possibly some belong to its subspecies *bicristata.* The collections need to be restudied to determine this point, which is suggested by the discrepancy between the several descriptions. If both subspecies are represented, those with more rudimentary oral muscles probably should be assigned to the subspecies *bicristata*, for the solitary form of this species has its oral muscles much less developed than do the solitary individuals of the species type which Apstein describes.

TRAUSTEDTIA RADIATA, new name, solitary form.

Salpa henseni Apstein, 1906, *b*. (This seems to be a homonym.)
S. multitentaculata Ihle, 1911 (part).

Apstein (1906, *a* and *b*) describes and figures this form and Dober (1912) gives a figure of it. As Dober's and Apstein's figures do not agree, both are included here (figs. 138 and 139).

Apstein (1906, *a*) says the form of the body is a short oval. It is rather flat and has a very thick test. No mention is made of any crests or ridges such as Apstein (1894, *b*) had already figured for *Traustedtia multitentaculata*, in his Plankton Expedition report.

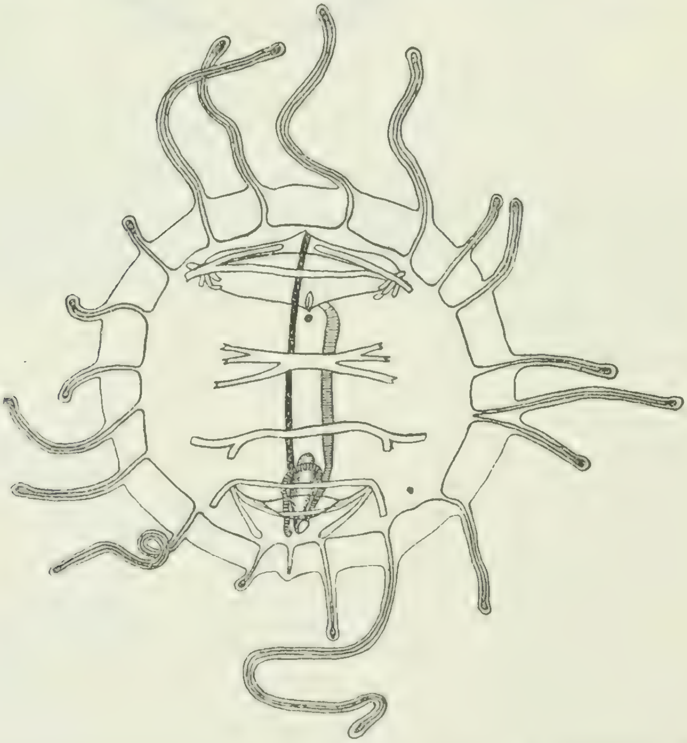

FIG. 138.—TRANSTEDTIA RADIATA, SOLITARY FORM, DORSAL VIEW. × 3½ DIAMETERS. FROM DOBER (1912).

Body muscles I, II, and III are either fused dorsally (fig. 136, Dober) or approximated (fig. 139, Apstein). Body muscle IV, according to Apstein, is branched as in the subspecies *bicristata*. Dober shows the posterior branch interrupted. Probably there was in his specimens a continuance of the muscle blood vessel bridging the space between the tip of this short branch and the point a little farther back where three bands meet.

The posterior branch of body muscle IV is crossed by a band which may be a fifth body muscle, or perhaps a basal atrial sphincter lying across the dorsal side of the base of the atrial siphon. Just beyond this band, body muscle IV, *b* divides into two branches as in the form *cristata*, one branch passing behind the visceral mass, the other running below the atrial siphon, where it meets its fellow from the opposite side, thus forming a basal atrial sphincter on the lower side of the siphon. The other atrial muscles are not well shown by Apstein, and I am not quite sure of them in Dober's figure.

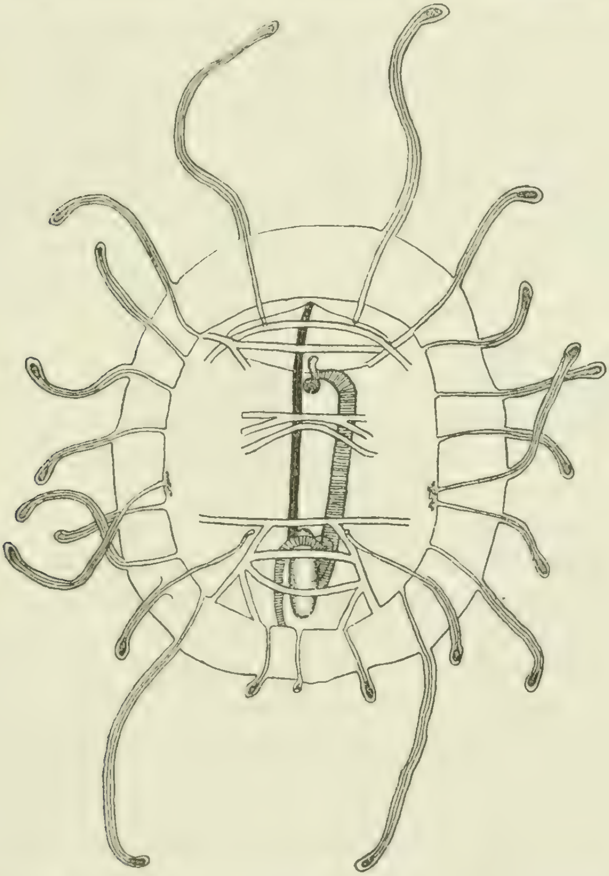

FIG. 139.—TRANSTIDTIA RADIATA, SOLITARY FORM, DORSAL VIEW. × 3½ DIAMETERS. FROM APSTEIN (1906, *b*).

The intermediate and oral muscles are quite differently figured by Apstein and Dober. The former shows what seems to be a very short intermediate muscle, a short oral retractor, and one complete sphincter in each lip. Dober's figure is not clear. It shows more muscles than Apstein depicts. Among them are a short intermediate muscle, an oral retractor, a delicate admarginal sphincter, which is complete, and a broader incomplete second sphincter, both in the lower lip, a broad complete first sphincter and an aborted very short second sphincter in the upper lip. This musculature is considerably different from that of either *Traustedtia multitentaculata* or its subspecies *bicristata.*

The gut differs from that of the other species of *Traustedtia* in lying in a more horizontal position. The stolon has a position similar to that in the form *bicristata.* The eye (Dober) is of the ususal horseshoe form.

The characteristic thing in this species is the presence of 20 (Dober) to 23 (Apstein) "tentacles," which Apstein describes as follows:

> Von der Leibeshöhle durchdringen den Mantel [test] eine Reihe Kanäle, von denen ich 23 zählte. Diese Kanäle setzen sich röhrenartig über die äussere Mantelfläche fort und werden vom Mantel mit dicken Wänden versehen. Gegen das Ende schwellen die Fortsätze an, auch der Hohlraum erweitert sich, ist aber geschlossen. Während die Salpe farblos war, sah ich in und an diesen Fortsätzen im Leben ein orange bis braunes und gelbes Pigment. Da, wo die Fortsätze die äussere Mantelfläche verlassen, wird der Hohlraum von einem orange Pigment umgeben. Oft fanden sich in der Mitte des Fortsatzes Querfalten und dann ebenfalls das orange Pigment in der dicken Wand des Fortsatzes. Der erweiterte Hohlraum am Ende war orange mit braun gefärbt, während die Wand in zartem Gelb schimmerte. Der Hohlraum shien meist leer zu sein, stellenweise fand sich eine feinkörnige Masse, deren Natur nicht erkennbar war. Am Vorder- und Hinterende fanden sich je 2 längere Fortsätze.

The shape of the body, the large number of "tentacles," the absence of crests and toothed ridges, the arrangement of the muscles,[1] and the position of the visceral mass, demarcate the solitary form of this species from that of either *Traustedtia multitentaculata* or its subspecies *bicristata.*

Apstein classed the radiate specimens in the collections of the German Deep-Sea Expedition in the same species, "*henseni,*" as those he studied in the collections of the Plankton Expedition, making no mention of the absence of crests and toothed ridges in the "Deep-sea" specimens, and ignoring the presence of a much greater number of "tentacles." His and Dober's drawings of the radiate forms can not represent *multitentaculata,* for the shape of the body and the shape and sculpturing of the test are very different in the latter species. It seems necessary to recognize these radiate individuals as a distinct species, which for obvious reasons I name *radiata.* This disposition of the matter must be regarded as tentative, pending restudy of the "Deep-sea" specimens.

THE TRAUSTEDITAS IN GENERAL.

Let me again suggest that reexamination of the solitary forms of *Traustedtia* in the collections of the Tiefsee and Plankton Expeditions may show the two tentative subspecies I have recognized, to be one. In that case Quoy and Gaimard's name *multitentaculata* will be retained for this species. But, as the published descriptions now stand, we must recognize two subspecies. It seems hardly possible that such restudy will show the form I have named *radiata* to be the same as *multitentaculata*, as Apstein thought, for both Apstein's and Dober's figures show a character quite divergent from the latter species.

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[1] Apstein (1906, *b*) in his discussion of the Tiefsee-Expedition specimens says "Die Muskulatur stimmt mit der früher beschriebenen überein." By this he must refer to his description of the single specimen in the collections of the Plankton Expedition, which he at first named *Salpa verrucosa,* and which I have assigned, from his description to the species *multitentaculata.* The musculature in the two forms, according to Apstein's figures, is really considerably different. Dober and Apstein both worked upon specimens collected by the Tiefsee-Expedition.

The arrangement of its muscles, and especially the character of its eyes, show that *Traustedtia* is more nearly related to *Pegea* than to any other subgenus.

The feature of the Traustedtias, which at first glance is most noticeable, is the presence of numerous tentacle-like processes in the solitary individuals. These all correspond in structure to the hollow protuberances found in its aggregated zoöids and in other species at the postero-lateral angles of the body. The Thalias show similar but less developed tubes at other points on the body. Some aggregated zoöids of *Thalia democratica*, especially those collected by the *Albatross* in Philippine waters, have numerous well developed tentacle-like processes, which very closely resemble those of *Traustedtia* (fig. 107, *C*, p. 114). In this connection we may remember that among the Ascidians—as among the Botryllidae—there are numerous tubular protuberances of the mantle into the test. The structures in the Salpidae seem essentially of the same character, though far more definite. The postero-lateral protuberances are symmetrically developed in the solitary forms of those species which bear them. In the aggregated zoöids, on the other hand, they are unequally devloped on the two sides of the body, as in *Pegea confederata bicaudata* and *Traustedtia multilentaculata*. It is quite possible that the single postero-lateral protuberance seen in the aggregated zoöids of the several species of the subgenus *Salpa* may be homologous with one of the pair present in *Pegea* or *Traustedtia*. It is doubtful how far this comparison may be carried, whether it may include the divisions of the postabdomen in the *Cyclosalpae* and the asymmetrical posterior processes in the other subgenera. The strict homology of these structures throughout the aggregated Salpidae is doubtful, but they are all in the same region of the body, are all protrusions of the test, which, so far as described, contain an inner tube of mantle tissue, the lumen of the tube being continuous with the spaces of the mantle.

THE SALPIDAE IN GENERAL.

STRUCTURE AND RELATIONSHIPS WITHIN THE FAMILY.

Such a review of the species of Salpidae, as we have made, brings out the falseness of the distinction usually used in taxonomic keys to separate the Salpidae from the Doliolidae. The muscle bands in the Doliolidae form complete rings, while in the Salpidae they are said to form incomplete rings: the animals of the former group being called *Cyclomyaria* (Gegenbaur), those of the latter group *Hemimyaria* (Herdman). Of course in many species of Salpidae, as Brooks (1893) long ago clearly showed, the muscle bands are complete. I suggest as preferable terms *Multistigmosa* for the Doliolidae, in which the pharyngeo-cloacal partition contains numerious stignata, and *Astigmosa* for the Salpidae, in which this partition has been reduced to a single axial rod, no stigmata being present.

Probably ancestrally the form and musculature of *Salpa* resembled somewhat that of *Doliolum* which, in the character of the stigmata and the relations in the nervous system, is more primitive than *Salpa*. Probably the primitive muscle schema consisted of a series of strong hoop-like bands around the body (the body muscles), and a series of more delicate sphincters at both the oral and atrial apertures. The body muscles in some of the Salpidae are still much in this condition, especially in the solitary individuals.

In the more aberrant subgenera of the Salpidae we observe a reduction in the musculature. In most species the aggregated zoöids show fewer body muscles than do the solitary zoöids of the corresponding species. Four is the usual number of the body muscles in the aggregated zoöids of the Cyclosalpas (three in *C. floridana*), five the number in the aggregated zoöids of all other species except *Ritteria hexagona* (six), the Thalias (four), *Pegea* (four), and *Traustedtia* (three or four, according to interpretation). The intermediate muscle is somewhat reduced in the Thalias, and is greatly reduced in *Thetys*, *Pegea*, and *Traustedtia*. In the solitary forms, reduction of the muscles is less usual, but in its extreme, in *Pegea*, is very marked. In the Cyclosalpas the solitary individuals show seven body muscles. In the Ritterias the number is large, being variable in at least some of the species. In the Apsteinias and the Salpas the number is eight or more. In *Iasis* the number is five. *Thetys* shows a very large number, confined however to the dorsal half of the body. *Thalia* has five, while *Traustedtia* and *Pegea* have but four developed as body muscles and these very short, especially in *Pegea*.

The atrial musculature in the Cyclosalpas conforms to the supposed ancestral schema and there is great departure from this schema among the Salpidae only in the subgenera which have modified the atrial siphon into a strongly two-lipped structure in which the upper lip is developed as an overhanging valve, that is, in *Iasis* and *Thalia*. The atrial retractor muscle is not readily recognized in some species with cylindrical atrial siphon (*Cyclosalpa pinnata*, pl. I, fig. 1, *a. r.*) though in others it is well developed (*C. virgula*, pl. 11, fig. 26). In more modified species the atrial siphon becomes two-lipped and in all these the atrial retractor is well developed.

The oral siphon in all forms is decidedly two-lipped and the oral musculature does not in any species show a simple series of regular circular sphincters.

Apparently the oral muscles, intermediate muscles, body muscles, and atrial muscles, should be regarded as serially homologous with one another, as *Doliolum* suggests. The intermediate muscle is developed in some species, in general the more primitive, to function with the body muscles. In the more modified species, especially those in which the musculature is reduced, the intermediate muscle functions with the oral muscles. Similarly between the body muscles and the definitive atrial sphincter muscles are one or often two bands which are intermediate in character between body muscles and atrial sphincters. A sharp line of demarcation between the two series of muscles does not generally exist.

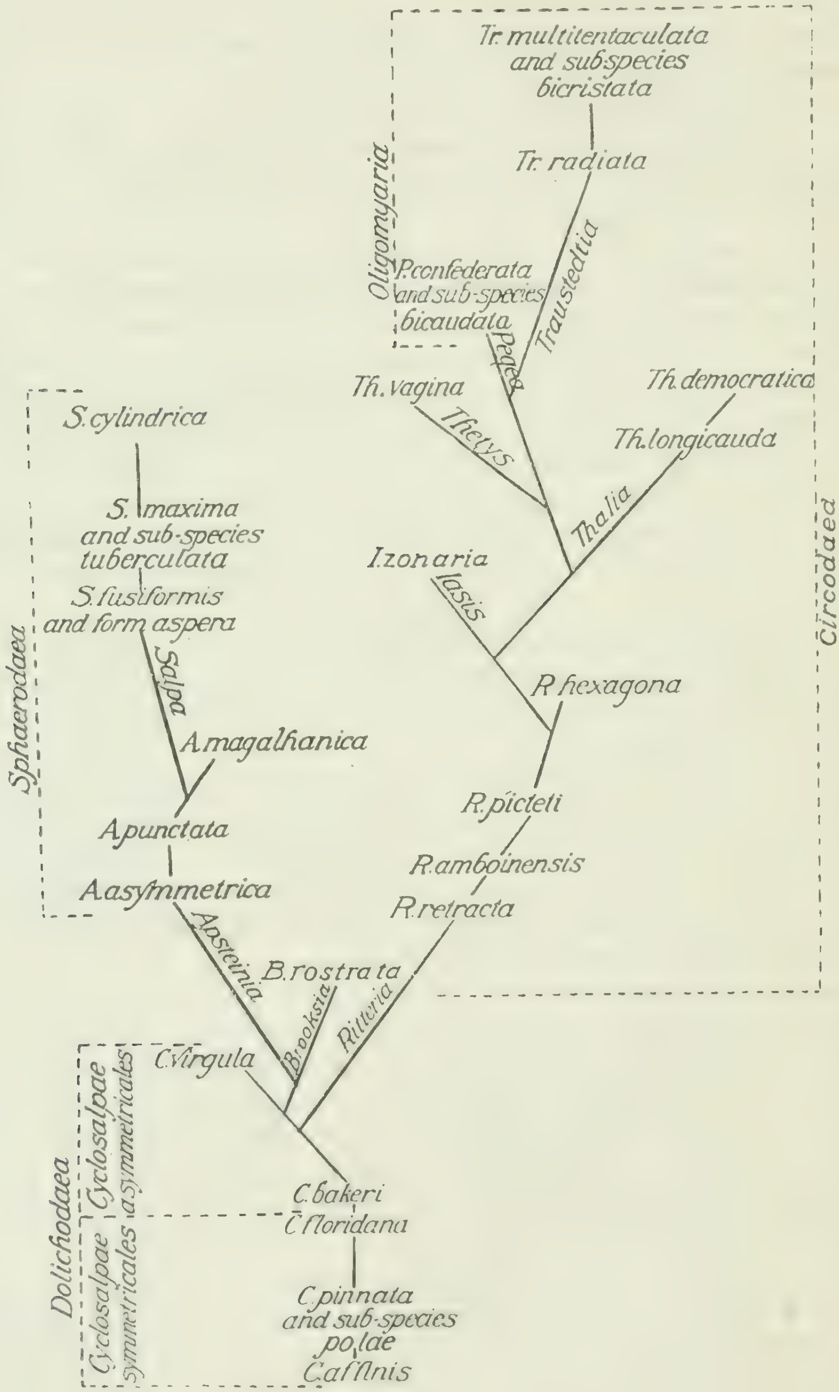
There is a reduction in the eyes of the aggregated zoöids in one of the more highly modified of the Salpidae, the anterior portion of the large dorsal eye seen in all other species, being wholly wanting in *Thalia*.

In *Thetys* the basal and terminal portions of the large dorsal eye are less distinct from each other than in most species, the eye being very compact, but both portions are recognizable in the arrangement of the rod and pigment cells.

The histological condition of the rod-cells of the large dorsal eye of the aggregated zoöids shows degeneration in the more modified sub-genera, as *Thetys* and *Pegea*. Their condition in *Traustedtia* is not known. The eyes within the ganglia of some species show similar histological degeneration, as *Pegea*, *Thetys*, *Ritteria hexagona*, and even *Salpa fusiformis* and *S. maxima*.

The neural glands, also, depart from the usual condition, in the more modified species, being united into one below the ganglion in *Iasis* and *Thetys*, and being wholly absent in *Thalia*. Even in *Salpa cylindrica*, not a highly modified species in general, the disks of the gland are absent and the ducts are only slightly developed. The outgrowths from the ganglion in connection with the neural glands are reduced to a single pair or are even unrecognizable in some of the more modified subgenera.

The conclusions as to relationships among the Salpidae, which I have reached from a study chiefly of the muscles, gut, and eyes, are shown graphically, though too definitely, in the accompanying chart. Upon the exact points of origin of the divergent lines of decent I would by no means insist, but the vividness of the graphic method of presentation outweighs the overemphasis upon some of the details which is necessarily involved in such a chart.


Tr. multitentaculata and sub-species bicristata
Tr. radiata
Oligomyaria
Traustedtia
P. confederata and sub-species bicaudata
Pegea
Th. vagina
Thetys
Th. democratica
Th. longicauda
Thalia
I. zonaria
Iasis
Circodaea
R. hexagona
R. picteti
R. amboinensis
R. retracta
S. cylindrica
S. maxima and sub-species tuberculata
S. fusiformis and form aspera
Salpa
A. magalhanica
A. punctata
A. asymmetrica
Sphaerodaea
Apsteinia
B. rostrata
Brooksia
Ritteria
C. virgula
Cyclosalpae asymmetricales
Dolichodaea
C. bakeri
C. floridana
Cyclosalpae symmetricales
C. pinnata and sub-species polae
C. affinis

The name *Cyclosalpa*, based upon the arrangement of the zoöids in the stolon in whorls, probably does not appropriately apply to the *Cyclosalpae asymmetricales*, and it would seem more natural to place these two species in a distinct subgenus, but the very close relationship between the species *bakeri* (asymmetrical) and *floridana* (symmetrical) is an obstacle to such division of the subgenus.

The scheme of relationship figured shows the Cyclosalpas as the primitive members of the family, from which two major divisions have descended. The more primitive species, with elongated intestine at least in the solitary forms, may be called the DOLICHODAEA. These are the *Cyclosalpae*. The species with a very compact gut forming a spheroidal mass in both solitary and aggregated forms may be named the SPHAERODAEA. This group includes *Apsteinia* and *Salpa*. The species with a curved gut, which, however, at least in the solitary individual, does not form a close "nucleus," may be called the CIRCODAEA. This group includes *Brooksia*, *Ritteria*, *Iasis*, *Thetys*, *Thalia*, *Pegea*, and *Traustedtia*. It is a much less compact group than either the Dolichodaea or the Sphaerodaea. This division, on the basis of the condition of the gut, seems accurately to express true relationship, but practically it is not so convenient as might be wished, for those of the Circodaea, which have a more compact gut, approach rather too closely for casual discrimination the condition of the Sphaerodaea.

Iasis and *Thalia* agree in the valvular character of the dorsal lip of the atrial siphon and the development of the dorsal atrial sphincters as a plexus. They also agree in the reduction of the neural gland in their aggregated zoöids. In *Iasis* (fig. 103, p. 108) it is a median chamber with right and left lobes and a single lateral duct, while in *Thalia* it is wholly absent. In *Thetys* the neural gland is a single median chamber (fig. 118, p. 126). Because of the resemblance in their neural glands and larger eyes in the aggregated zoöids, *Iasis* and *Thetys* seem to be somewhat near relatives, in spite of the great difference in their muscles. *Thalia* seems much more nearly related to *Iasis* than to *Thetys*.

Among the Circodaea there is greater instability of the muscular system, the eyes, and the neural glands. The musculature is overemphasized in the *Ritterias*, the more primitive members of this division, while in the more aberrant forms, *Pegea* and *Traustedtia*, it becomes much reduced. The term OLIGOMYARIA might well be limited to these two subgenera.

The eyes of the aggregated zoöids become increasingly degenerate in the more aberrant forms. The aggregated *Iasis* and *Thetys* show the dorsal eye very compact. Degeneration of the rod-cells begins in *Iasis* and goes far in *Thetys*. In the aggregated *Thalia* the apical portion of the large eye is missing, while in the aggregated *Pegea* and *Traustedtia* no inversion of the eye occurs. *Brooksia*, in its affinities, leans perhaps toward the Sphaerodaea, the aggregated zoöid being very asymmetrical, more so than in *Ritteria*, though its gut is described as less compact than is the gut in *Apsteinia* or *Salpa*. Its aggregated zoöids show marked resemblance to those of the most highly modified of the *Cyclosalpae*, *C. virgula*. The remarkable anterior protuberance in the solitary *Brooksia* seems to resemble in a general way the anterior protuberances seen in the aggregated zoöids of all the subgenus *Salpa*.

The most primitive of the Salpidae—the *Cyclosalpae symmetricales*—I suggest, may owe the absence of symmetry in their aggregated zoöids to their arrangement in the form of a wheel. The presence in the eye of *Cyclosalpa pinnata* of a slight though constant asymmetry (see p. 10) suggests that even the symmetrical Cyclosalpas may have been at one time more asymmetrical. The wheel-like grouping of their aggregated zoöids is probably a secondary character. The higher Cyclosalpas have very asymmetrical aggregated zoöids, so also do the more primitive members of the two major divisions derived from the Cyclosalpas, but the most aberrant members of the family Salpidae show decreasing asymmetry in the aggregated forms. All, however, show some asymmetry, however disguised. The position of the large eye in the aggregated zoöids is asymmetrical in all of these aberrant species.

In the group Salpidae, hybridization is not known. Each species is clearly demarcated. The two subspecies, *Cyclosalpa pinnata polae*, and *Pegea confederata bicaudata*, are definite. *Salpa fusiformis*, form *aspera*, seems hardly to be worthy of rank as a subspecies, for it completely intergrades with the species proper. On the other hand the tuberculate variety of *Salpa maxima* is not known to intergrade with the species itself.

The question of treatment of genera and subgenera, species, and subspecies is one a little troublesome to decide. If we are to define and use the term species with strict scientific accuracy I suppose every persistent mutant, however slightly it diverges, must be classed as a distinct species. Any other classification would be purely subjective, dependent upon the judgment of the student as to the importance or nonimportance of the diversities observed. Species and genera, as they are employed in classification, are largely conventional. They must be so, for the recognition in our taxonomic systems of every distinct mutant would be utterly impossible, and there is no criterion for genera which removes the personal equation of the observer. The question then, in its practical aspects, is one of convenience and of the best expression of probable relationship. I have chosen to treat as subgenera rather than genera the groups

Cyclosalpa, Brooksia, Apsteinia, Salpa (proper), *Ritteria, Iasis, Thetys, Thalia, Pegea*, and *Traustedtia*. This seems more convenient, in view of the long established use of the genus name *Salpa*. These groups are far more worthy of emphasis as genera than are many groups, in other families, which are recognized as genera. It has not seemed worth while to place the species *hexagona* in a distinct subgenus, though it diverges considerably from the other *Ritterias*. The resemblance is probably more deserving of emphasis than the divergence. Similarly the resemblance of the species *virgula* to the other *Cyclosalpas* seems more worthy of emphasis than its considerable divergence.

Treating as subspecies varieties and formae the forms *polae, tuberculata, aspera, bicaudata*, and *bicristata* seems reasonable, for their close similarity, respectively, to the species *pinnata, maxima, fusiformis, confederata*, and *multitentaculata* seems much more worth emphasizing than does their divergence each from its respective species. *Bicaudata* and *polae* are clearly good subspecies. The tuberculate variety of *Salpa maxima* is, so far as known, a sharply distinct variety, but the form *aspera*, as noted, completely intergrades with *S. fusiformus*. Of course it would be of interest to know from observed breeding, in each of these cases, if the species ever "throws" the subspecies as a sport. This, apparently, we are likely never to know. There is no sufficient reason for supposing that this does occur. We must take the forms as we find them and endeavor in our taxonomy to make the clearest expression of probable relationship.

SPECIATION.

The very considerable diversity of the species within the family Salpidae is correlated with the great specialization of the family for its pelagic life. The two sets of phenomena are but different phases of the fundamental physiological quality of plasticity. This plasticity, as indicated in the later stages of the evolution of the family, during the time of formation of the diverse species, seems due not to sensitiveness in response to environmental influences, but more probably to an inherent instability working itself out in many directions, without special relation to environmental influence. The external conditions under which the several species live are remarkably uniform. Their divergence has not been in the nature of fitting into different types of environment. It must have resulted almost wholly from inherent qualities.

One naturally asks if there is evidence that hybridization has had a part in this trend toward divergent speciation in the family. Of course, in the complete absence of paleontological evidence, we can not say what may have been in the past, but there is no evidence of hybridization to-day in the family. In this regard the Salpidae are sharply contrasted with the Pyrosomidae which show such intergradation between species as strongly to suggest hybridization.

Frequent reference has been made in this paper to the comparative stability of the solitary form and the greater divergence of the aggregated zoöids. The life cycle of a salp begins with the egg and includes first the solitary form, then its buds. The fully formed aggregated zoöid is the final stage of the ontogeny. It is, of course, in line with the conditions in other groups of animals to have the later stages of the ontogeny more divergent among the several species than are earlier stages, provided environmental conditions are uniform throughout the life cycle.

ORIGIN OF THE SALPIDAE.

In any taxonomic discussion of the Salpidae, reference should be made to the origin of the family and its relationships to other groups of the Tunicata.

In their adult structure there seems no clear evidence of near relationship between *Pyrosoma* and the true Thaliacea (*Doliolum*, *Anchinia*, and *Salpa*), nor does there appear evidence of closer relationship of the Thaliacea to any of the compound Ascidians. The evidence from the manner of budding will be discussed a little later.

Among the attached Ascidians, both simple and compound, the most archaic seem to be the Clavelinidae. Budding was probably acquired as a means of reproduction soon after the habit of attachment was formed, sedentary life among both plants and animals apparently tending toward asexual reproduction. In all families, in the Tunicata, in which budding occurs, it is by means of a proliferous stolon of the same general type, which is a prolongation of the epicardial tube, with associated mesodermal strands, into a cylindrical outgrowth of the epidermal epithelium. Outgrowths from the atrium may or may not be included in the stolon.

The Simple Ascidians other than the Clavelinidae—that is, the Ascidiidae, the Cynthiidae, and the Molgulidae—have no proliferous stolon, though they show an epicardial tube. We have no evidence to determine if this absence of a stolon is primitive or secondary in these three families. At any rate, their adult structure is more complex than that of the Clavelinidae, which seem the most archaic sedentary members of the phylum now living.

The Larvacea are in many features much more archaic still. They have an elongated form with locomotor tail, a hollow dorsal nervous axis, a notochord lying in part at least between the nervous and alimentary tubes, and lateral skeletal muscles are present in the tail. There is a typical chordate endostyle, and there are gill slits opening into atrial pouches which may or may not be homologous to the atrium of *Amphioxus* and the "atrial" furrows of *Balanoglossus*. The Larvacea show in their structure no indication of having had in their ancestry Ascidianlike forms. All their structure may well have been evolved during pelagic life. This is especially true of their remarkable test ("house") which is their most specialized feature.

The adoption of sedentary life led to change of form, accompanied by loss of the tail with its axial skeleton, its elongated nerve tube and its skeletal muscles, and to special development of the food collecting organ, the pharynx with its gill basket. Increased size also followed, and concomitantly the remnant of the nerve tube enlarged into the cerebral ganglion. As is so usual with sedentary forms, asexual reproduction was emphasized. *Clavelina* gives us our best picture of this stage of evolution in the phylum.

From some such early sedentary Ascidians apparently diverged several lines of descent. By one or more of these the nonbudding simple Ascidians arose, or they may have arisen before the budding habit was developed. By another line *Octacnemus* arose. Still another line, or possibly several independent lines, gave us the compound Ascidians, from which in time arose the secondarily pelagic *Pyrosoma*. The origin of *Pyrosoma* from compound Ascidians seems indicated by the remarkable Distomid, *Cyathocosmus mirabilis*. (See Oka, 1912 and 1913, also Metcalf and Hopkins, 1918). A final line, of doubtful origin, which early branched dichotomously, developed, on the one hand, into the Doliolidae, on the other, into the Salpidae.

The presence of a sedentary stage in the ancestry of *Doliolum* and *Salpa* is indicated by the possession by these two forms of features first acquired as an adaptation to sedentary life, that is, the large size, the short compact nervous system, the extensively developed branchial basket, and the great development of asexual reproduction.

Doliolum and *Anchinia*, returning to pelagic life, take with them their large size, their compact ganglion, their complex pharynx and highly developed atrium, all acquired under sedentary conditions. They adopt the barrel-shaped form of body, moving the mouth and atrial aperture to opposite ends of the body, modifying the sphincter muscles of their two siphons into a series of hoop-like muscles, whose contractions narrow the whole body, causing expulsion of water from the atrial opening and this propelling the body forward. The branchial basket moves backward from the two sides of the pharynx to form a transverse lattice-work between the pharynx in front and the atrium behind, which now has lost its peribranchial outgrowths.

The structural modification of the Doliolidae from the Ascidian condition is considerable, but their chief feature of specialization is the great development and the unique character of their asexual reproduction with migrating polymorphic buds.

The Salpidae have passed a little beyond the Doliolidae in structural development. Their muscle bands are less regular; the branchial basket is lost by the fusion of all the stigmata on each side of the raphe into a single large opening, the pharyngeo-atrial partition being reduced to a mere rod; the dorsal part of the ganglion has developed into an eye of a type new to the Tunicata; and the old type of neural gland, derived from the central nerve tube, is lost, and one of a new sort, developed from the pharyngeo-atrial epithelium, is substituted. In its structural features *Salpa* is the most modified of all Tunicata. Its processes of budding, however, are far simpler than those of the Doliolidae, and there is in *Salpa* no indication that it ever had and has lost a very complicated series of bud forms such as the Doliolidae show. *Doliolum* is clearly Salpa's nearest relative, but the two must have diverged before the acquirement of polymorphism in the buds upon the stolon. *Salpa* passed on to higher structural modification, retaining a comparatively simple series of buds. *Doliolum*, remaining less modified in structure, has evolved a most complicated process of budding with decided polymorphism among the buds. Structurally *Salpa* is the most highly evolved of the *Tunicata.* In their life history the Doliolidae are the most elaborate.

It has generally been thought that the Doliolidae, structurally the more primitive branch of this last line, arose from *Pyrosoma*-like forms, the evidence usually cited being the simple character of the branchial basket in the two groups and the position in both of the oral and atrial apertures at opposite ends of the body. The latter seems a point of little weight, for it is a simple adaptation to environmental conditions, and might readily be independently acquired in the two families. After such change in the siphons, the condition of the branchial basket would be as readily derived from that of the Clavelinidae as from that of *Pyrosoma.*

A comparative study of the methods of budding, however, gives some indication that the Doliolidae and Salpidae probably arose from somewhat *Pyrosoma*-like forms. In *Pyrosoma*, *Doliolum*, and *Salpa* the stolon is more complex in structure than in the Ascidians, but is more primitive in the relations of the several organs to the germ layers. In the Ascidians all the internal organs of the bud are derived from the epicardial tube of the stolon, which is of course endodermal. Even the atrium and nervous system arise from this endodermal tissue. This of course is a very secondary condition.

The *Pyrosoma* cyathozoöid has a more primitive stolon in two regards. The lateral tubes of the stolon, which give rise to the atrial chambers of the buds (ascidiozoöids), arise from the atrial chamber of the parent, very near its aperture. These are therefore ectodermal, as is natural. The nervous systems of the buds arise from rods and tubes of cells which are formed by proliferation from cells of the ectodermal sheath of the stolon. These nervous systems are therefore ectodermal.

In *Salpa* the atrial tubes of the stolon, which form the atrial chambers of the buds, arise from the atrium of the parent, thus resembling *Pyrosoma*. In *Doliolum* the conditions need further study. Atrial tubes are present, and from them arise the atrial chambers of the buds, but it is not known from what source in the parent, or in the stolon, these atrial tubes arise. In *Salpa* the nervous systems of the buds are derived from a neural rod and tube in the stolon, and this arises by proliferation from the ectodermal sheath, at the base of the stolon. The conditions are therefore as in *Pyrosoma*. In *Doliolum* the nervous rudiments of the buds are at first double, one coming from each atrial tube; later they unite. *Doliolum* is therefore aberrant in having the nervous systems of the buds arise from the atrial tubes while in *Pyrosoma* and *Salpa* they arise from the ectoderm at the base of the stolon. The distinction is probably not fundamental, as at first it appears, for in *Pyrosoma* the atrial tubes of the stolon arise from the ectoderm of the atrium, near where it opens out to the surface ectoderm.

Pyrosoma, *Doliolum*, and *Salpa* have well-developed mesodermal strands in the stolon which give rise to the gonads and the muscles (*Pyrosoma* ?) of the buds.

In complexity of structure of the stolon, and in the relations of the organs in the buds to the germ layers, *Pyrosoma*, *Doliolum*, and *Salpa* agree, and are in sharp contrast to the Ascidians. The former three agree also in having the buds on the stolon, at least when they first appear, arranged in a linear series, all with their ventral surfaces toward the distal end of the stolon. These resemblances between these three forms in their manner of budding seem fundamental and not due to secondary convergence. We must therefore believe that the *Doliolum-Salpa* line of descent arose from forms which had already acquired the *Pyrosoma* type of stolon.

Pyrosoma shows two types of colony formation—one by means of migrating buds, the other by means of permanently attached buds. *Doliolum* shows the migrating type of buds. The origin of this migration in a definitively *Doliolum*-like form is very difficult to imagine. It seems more probable therefore that *Doliolum* has come from a colonial animal like *Pyrosoma*, which had already, in its colony formation, developed migrating buds. It is worth noting that in both the *Pyrosomata ambulata* and in *Doliolum* the buds, when formed, detach from the stolon and migrate to the dorsal side of their parent, there to take a position definitely oriented with reference to the parent, though their orientation is different in the two groups. (See Metcalf and Hopkins (1918), p. 017).

We see, therefore, that while the comparative anatomy of the adult Tunicata tells us little of the origin of the Doliolidae and Salpidae, the comparative study of the manner of budding gives us reason for believing that *Doliolum* arose from *Pyrosoma*-like ancestors, by giving up the compact colonial form, and that from *Doliolum*-like ancestors arose the Salpidae.

DISTRIBUTION OF THE SALPIDAE.

The distribution of the Salpidae has been studied chiefly by Traustedt (1893), Apstein (1894, *b*, 1901, 1904, 1906, *a* and *b*), and Ihle (1910).

Apsteinia asymmetrica is known from the equatorial Atlantic Ocean off Africa (Apstein, 1906, *b*) and from the North Atlantic Ocean east of Iceland (Fowler, 1896).

Apsteinia magalhanica is known from the Straits of Magellan (Apstein, 1894) and off the Cape of Good Hope (Apstein, 1906, *b*). We have not studied this species.

Apsteinia punctata is known from the western Atlantic Ocean off Bermuda (Traustedt, 1893), from the central equatorial Atlantic Ocean (Apstein, 1906, *b*), from the East Indies (Ihle, 1910), and it is more frequently found in the western Mediterranean Sea. Our material is from Naples, probably collected in the western Mediterranean Sea.

Brooksia rostrata is known from the western (Apstein, 1906, *b*) and central (Traustedt, 1893) north Atlantic Ocean, from the western and central equatorial Atlantic Ocean (Apstein, 1906, *b*), from the southern Indian Ocean (Apstein, 1906, *b*), and from the East Indies (Ihle, 1910). We have had no specimens of this rare salpa.

Cyclosalpa affinis was one of the earliest forms discovered and has been often collected. It has been reported from the eastern and central North Atlantic Ocean, also from east of Bermuda, from the eastern and central equatorial Atlantic Ocean, from the western Mediterranean Sea, from the northeastern and the northwestern Indian Ocean, from off the east coast of Australia, from the eastern Pacific Ocean from southern California to Hawaii and southward. We add from our collections a station in the northwestern Atlantic Ocean off Marthas Vineyard, and stations in the northern Pacific Ocean off the California and Alaska coasts and in Bering Sea.

Cycolsalpa bakeri has been reported from the coast of southern California (Ritter, 1905), and from the southern East Indies (Ihle, 1910). Apstein (1906, *a*) describes and figures as *Cyclosalpa floridana* a form which is really *C. bakeri*, failing to distinguish between the two species. In this paper he gives the following localities for "*C. floridana:*" Off the west coast of Africa from the Equator to the Cape of Good Hope, the northeastern Indian Ocean, and off the Somali coast of Africa. Some of the salpas so reported were *Cyclosalpa* *bakeri;* some may have been *C. floridana.* The distribution of these two species is therefore uncertain. The collections of the Tiefsee Expedition should be restudied in reference to the distribution of these two species. Our collections show *Cyclosalpa bakeri* present in Philippine waters, 1,200 miles north of the East Indian region, in which it was found by the *Siboga* Expedition.

Cyclosalpa floridana has been reported from the northwestern Atlantic Ocean, 400 miles south of Newfoundland and southward (Apstein, 1904, *b*). Apstein may have included among the specimens reported some *Cyclosalpa bakeri*, which later he confused with *C. floridana.* The collections of the Plankton Expedition, as well as those of the German Deep-Sea Expedition, should be restudied with reference to the distribution of these two Cyclosalpas. Some of the specimens collected by the latter expedition and reported by Apstein (1906, *b*) as *Cyclosalpa floridana* were *C. bakeri;* others may have been *C. floridana.* The localities given by Apstein include the western Atlantic Ocean east of Bahama and the West Indian Islands; off Cape Verde; the central equatorial Atlantic Ocean; the west coast of Africa at the Equator and near the Cape of Good Hope; also the eastern, central and western Indian Ocean. Our collections add no new localities except to show the species present in the Gulf of Mexico and in the Gulf Stream off the coast of Florida and off the New England coast, and so nearer to the American coast than previous records show.

Cyclosalpa pinnata, the first discovered and probably the best known of the Salpidae, has been reported from the West Indies and the whole of the North Atlantic Ocean, both east and west, as far north as 56° north latitude, from the western Mediterranean Sea, from the equatorial and southern Atlantic Ocean, both east and west, to 23½° south latitude (off Rio de Janeiro), from the eastern and western Indian Ocean, from the Malay Archipelago, from southeast of Formosa, and from the eastern Pacific Ocean west of Panama. Our collections add localities in Philippine waters, and in the northern Pacific Ocean in Hawaiian waters and off the coasts of Lower California, Oregon, and Alaska as far north as 53° 6′ 3″ north latitude.

Cyclosalpa pinnata, subspecies *polae,* has been known only from the eastern Mediterranean Sea (Sigl, 1912, *a* and *b*). It is represented in our collections by three specimens of the solitary form from the Hawaiian Islands.

Cyclosalpa virgula, has long been known from the western Mediterranean Sea. It has been reported more recently from the eastern equatorial Atlantic Ocean (Apstein, 1906, *b*) and from the central Indian Ocean (Apstein, 1906, *b*). Our specimens were obtained from the Naples Zoological Station, and were doubtless collected in the western Mediterranean Sea.

Iasis zonaria, a very widely distributed and rather abundant species, has been reported from the whole Atlantic Ocean from 40° south latitude to Iceland and the coast of Greenland, the westernmost stations in the north Atlantic Ocean being east of the Bahama Islands and the eastern end of Cuba. It has been reported also from the western and central Mediterranean Sea, from all parts of the Indian Ocean, from the East Indies and Australasia north to Japan, and from the eastern Pacific Ocean from the Straits of Magellan to southern California. Our collections add stations along the east coast of North America from the mouth of Chesapeake Bay to Halifax, Nova Scotia, and numerous localities in the northern Pacific Ocean off the California and Alaska coasts to 56° north latitude.

Thetys vagina, the largest of the Salpidae, has been reported from the eastern Atlantic Ocean from 30° south latitude to the English Channel, from the western Atlantic Ocean east of the Bahama Islands, from the western Mediterranean Sea, from the southern and western Indian Ocean, from the western Pacific Ocean from New Zealand to Japan and eastward (but not from the East Indies), from the central south Pacific Ocean and from off the southern California coast. Our collections add a northwestern Atlantic Ocean station in the Bay of Funday, stations in Philippine waters, and stations in the eastern Pacific Ocean from the California coast to Behring Sea.

Pegea confederata, the most abundant species in the Philippine collections, is a widely distributed form and is apparently abundant throughout its range. Most students have failed to distinguish between this form and its subspecies *bicaudata*. The reports of its occurrence are therefore probably based in part upon collections of the form *bicaudata*. Ignoring this source of error, we may give the reported localities for *P. confederata* as follows: the eastern Atlantic Ocean from the Cape of Good Hope to the English Channel, the eastern and western Mediterranean Sea, the western south Atlantic a thousand miles east of Argentina, all regions of the Indian Ocean, the East Indies and the China Sea, and the southern, equatorial, and northern Pacific Ocean from 35° south latitude to the coast of southern California. Our collections add many stations in Philippine waters, and many along the whole eastern coast of America from the Florida Straits to New England (Marthas Vineyard Island). The absence of records of occurrence in northern Californian and Alaskan waters confirms the indication from the distribution in the Atlantic Ocean and shows this species to be a warm-water form.

Pegea confederata, subspecies *bicaudata*, has been reported from the Mediterranean Sea (Quoy and Gaimard, 1827, Krohn, 1846, and others), from the Indian Ocean (Lesson, 1832), from the southern Pacific Ocean (Apstein, 1894), and from the East Indies (Apstein, 1894). Probably some of the reports of *Pegea confederata* are based upon specimens of the subspecies *bicaudata*. Our collections contain specimens from numerous stations along the Atlantic coast of America from Cape Hatteras to Cape Cod. Probably, when this subspecies shall be recognized as distinct from the tailless form, it will be reported from some at least of the other regions included in the reports of *Pegea confederata*. In our Atlantic Ocean collections *bicaudata* is found at fewer stations than *confederata*, and in our collections from the eastern Pacific Ocean it does not occur at all. It is surely rare in Philippine waters, if it occurs there. It must also be rare or absent off the southern California coast or Ritter would have reported it ere now.

Ritteria amboinensis has been reported by Apstein (1906, *b*, and 1904) from the equatorial and southern Atlantic Ocean off the coast of Africa, from the western and the northeastern Indian Ocean, and from the southern East Indies. Ihle (1910) also reports it from the East Indies. It is represented in our collections by a dozen specimens of the solitary form from the central Philippine waters.

Ritteria hexagona is a warm water species. It has been reported from the eastern Atlantic Ocean (Madeira Islands), from east of the Cape of Good Hope, from the northern Indian Ocean, from the southern East Indies, and from between New Zealand and Australia. Our collections add numerous stations in Philippine waters.

Ritteria picteti. This rare form has been reported by Apstein (1904) and by Ihle (1910) from the East Indies, and by Apstein (1906, *b*) from off the Somali coast of Africa. It is not represented in our collections.

Ritteria retracta. The first specimen of this species was collected in Suruga Bay, Japan (Ritter, 1906, *b*). The Tiefsee Expedition found other specimens. Apstein (1906, *b*) confused these with "*Salpa amboinensis*," so that the data as to distribution is not usable.

Salpa cylindrica, a species long known, has been reported from the northwestern, central, and southeastern north Atlantic Ocean, from the whole equatorial Atlantic Ocean, from the southern Atlantic Ocean west of the Cape of Good Hope, from the northwestern, the northeastern, and the southern Indian Ocean, from many stations throughout the East Indies, from off Formosa, from the eastern Pacific Ocean off the coast of Chile, and off southern California. Our collections add stations in the West Indies, numerous stations in the eastern Pacific Ocean near the Hawaiian Islands, and off the California and Alaska coasts and in the Bering Sea. Numerous stations in Philippine waters are also represented.

Salpa fusiformis, one of the earliest known and most abundant of the Salpidae, has been reported from the whole Atlantic Ocean from 55° south latitude to 60° north latitude, from the whole Mediterranean Sea, from the whole Indian Ocean and Antarctic waters to 65° south latitude, from the East Indies and the east coast of Australia, from the east coast of Japan north to 50° north latitude, from the central equatorial Pacific Ocean, from the eastern Pacific Ocean between 40° south latitude and 30° north latitude. Our collections give additional localities—the West Indies and the Pacific coast of North America from California into Bering Sea.

Salpa fusiformis, form *aspera*. This form, which in our collections is more abundant than the smooth form, has been reported from the eastern Atlantic Ocean from 50° south latitude to 20° north latitude, from the northeastern, the northwestern, and the extreme southern Indian Ocean, from the East Indies, from between Japan and Kamchatka, from the Straits of Magellan, and the eastern Pacific Ocean from 40° south latitude to 15° north latitude, and from the southern California coast. Our collections add localities off the eastern coast of North America from Cape Hatteras to Halifax, Nova Scotia, and in the eastern Pacific Ocean from Hawaii to the central California coast and north to Puget Sound. Our collections also include many specimens intermediate between the smooth form and the fully developed asperate type. These are from the eastern and western coasts of the United States.

Salpa maxima, one of the earlier known species, has been reported from the whole eastern and southern Atlantic Ocean, from the whole Mediterranean Sea, from the southern Indian Ocean both east and west, from Cape Horn, and off the coast of Chile. Our collections add localities as follows: the western north Atlantic Ocean, off South Carolina and off Chesapeake Bay, the eastern Pacific Ocean between Hawaii and California and along the coast from San Francisco to Bering Sea, and the western Pacific Ocean (Philippine waters).

Salpa maxima, variety *tuberculata*, is a new variety collected by the Bureau of Fisheries' steamer *Albatross* in Philippine waters.

Thalia democratica, the most abundant of the Salpidae, is also very widely distributed, having been reported from all tropical and temperate seas except the eastern Mediterranean Sea, West Indian waters and the northern Pacific Ocean north of 30° north latitude. Our collections add the Gulf of Mexico (west coast of Florida), the Carribean coast of the Isthmus of Panama, the Atlantic coast of the southern United States (off Cape Hatteras), and the Hawaiian Islands. The prevalent Atlantic form differs from the more common Philippine type.

Thalia longicauda, though known since Quoy and Gaimard's description (1826–1834), and though sometimes very abundant when found, has been reported but seldom and from but few stations. Traustedt (1885) reports it from the southeastern Atlantic Ocean and from the southwestern Indian Ocean. Apstein (1906, *b*) reports it from the southeastern Atlantic Ocean, from the southwestern and central Indian Ocean, and from the east coast of Australia. The species is not found in our collections.

Traustedtia multitentaculata is a very rare species, first reported by Quoy and Gaimard (1826–1834) from the East Indies (New Ireland). It has since been reported from the southern Brazilian coast (Traustedt, 1893), from south of the Equator off the west coast of Africa (Dober, 1912), from the north Atlantic Ocean near Madeira (Apstein, 1906, *b*) and near the Azores (Apstein, 1894, *b*), and again from the East Indies (Amboina, by Apstein, 1904).

Traustedtia multitentaculata, subspecies *bicristata*, is represented by a single specimen of the solitary form from the north Atlantic Ocean, off the New England coast.

Traustedtia radiata, another very rare species, was first reported by Apstein (1906, *b*) from the eastern and western Indian Ocean (Tiefsee Expedition, station 182, north of Cocos Island, and station 235, north of Madagascar). This species is not represented in our collections. Its validity as a species is doubtful, pending the reexamination of the material.

UNIDENTIFIABLE SPECIES OF SALPIDAE AND SPECIES OF DOUBTFUL VALIDITY.

Unidentifiable species of Salpidæ and species of doubtful validity are named below alphabetically with a word of comment. In the preparation of this list I am much indebted to Traustedt's (1885) detailed bibliographic studies. Identified species are named in the synonomy lists under each species.

Biphora depressa SARS, 1829, is said by Traustedt (1885) to be *S. fusiformis*. I have not succeeded in finding in this country this paper of Sars's.

Holothuria denudata LINNAEUS, 1758 [=Browne's (1756) *Thalia* no. 3].

Pterolyra beroides LESSON, 1832, not a salpa.

Salpa amphoraeformis LESSON, 1832, apparently not a salpa.

S. antarctica MEYEN, 1832, can not be identified.

S. antheliphora PERON and LESUEUR, 1807, (*antheliophora*, MEYEN, 1832) can not be identified.

S. bicornis CHAMISSO, 1819, can not be identified.

S. biennis DE BLAINVILLE, 1827, may have been *Ritteria hexagona*.

S. bipartita BORY DE ST. VINCENT, 1804, not a salpa.

S. clostra MILNE-EDWARDS, quoted by Cuvier (1828), is said by Traustedt (1885) to be *S. fusiformis*. I have not found Milne-Edwards' reference to this species.

S. cyanea DELLE CHIAJE, 1828, may have been *Cyclosalpa pinnata*.

S. cyanogaster PERON, 1807, Traustedt thinks this may have been *Thalia democratica*. I do not see that it can be identified.

S. cymbiola DALL, 1872, apparently *S. fusiformis*, aggregated zoöid. This is indicated both by the published description and by the unpublished drawings which Dr. Dall has kindly shown me.

S. dolium QUOY and GAIMARD, 1826–1834, can not be identified with certainty. It may have been *Pegea confederata*.

S. dubia CHAMISSO, 1819, probably *S. africana*, aggregated zoöid.

S. dubia LESSON, 1832, apparently not a salpa.

S. elongata QUOY and GAIMARD, reference in de Blainville (1827), is said by Traustedt (1885) to be *S. cylindrica*. I have not found Quoy and Gaimard's description of this species. De Blainville's reference is insufficient for identification.

S. emarginata Quoy and Gaimard, 1824, can not be identified.

S. fasciata Forskål, 1775 (quoted by Bruguiere, 1789, Lamarck, 1816, and de Blainville, 1827), Traustedt (1885) thinks this may have been *S. fusiformis*.

S. forskalii Lesson, 1832, is said by Traustedt (1885) to be *S. maxima*, and the identification seems probable because of the size of the animal.

S. fusiformis Cuvier, 1804. There is confusion in Cuvier's paper. An aggregated zoöid of *S. fusiformis* is called *S. cylindrica* and a solitary *Pegea confederata* is named *S. fusiformis*. Strictly the reference "*S. fusiformis*, Cuv., 1804," is mistaken and one can not be wholly certain of Cuvier's intention. It is best, however, to let the reference stand, interpreting the discrepancy as mere confusion.

S. garnotii Lesson, 1832, shows a general resemblance to *S. cylindrica*, but can not be identified.

S. gibba Bosc, 1802, is said by Traustedt (1885) to be *Pegea confederata*, but the identification seems to me doubtful.

S. herculea Dall, 1872, is apparently *Thetys vagina*, as is shown by Dall's unpublished drawings, which he kindly showed me.

S. informis Quoy and Gaimard, 1824, probably *Pegea confederata*, as is indicated by the two sets of body muscles.

S. laevis Lesson, 1832, can not be identified.

S. lineata Lesson, 1832, can not be identified.

S. mollis Herdman, 1888, a doubtful form based on a single imperfectly preserved specimen. Possibly it may be a somewhat aberrant solitary individual of *S. fusiformis*, subspecies *aspera*.

S. moniliformis Macculloch, 1819, is said by Traustedt (1885) to be *S. fusiformis*. Hopkinson (1913) questions its being a salpa at all. I have not found the reference in Macculloch's paper. Fleming (1842), referring to Macculloch's description, says, "At each extremity of the back [the dorsal and ventral sides were generally reversed in early descriptions of Salpas] there is a conical longitudinal process nearly equal to the body in length." If this be a salpa at all it must be *S. fusiformis*, aggregated zoöid, unless, indeed, it is *S. maxima*, variety *tuberculata*, which seems altogether improbable.

S. neapolitana Delle Chiaje, 1841, probably *Thetys vagina*.

S. nitida Herdman, 1888, probably not distinct from *Iasis zonaria*, but merely a delicate form. The aggregated zoöids show a dorsal eye and a remarkable pair of lateral outgrowths from the ganglion, containing irregular rod-cells, all of which seem from Herdman's figures to be identical with the corresponding structures in *Iasis zonaria*.

S. pelasgica Bosc, 1802, is said by Traustedt (1885) to be *Cyclosalpa pinnata*, but the identification seems to me very doubtful.

S. polymorpha Quoy and Gaimard, 1824, not a salpa.

S. pyramidalis Quoy and Gaimard, 1826–1834, probably *Thalia democratica*.

S. pyramidalis Lesson, 1832, probably *Salpa fusiformis*.

S. quadrangularis Lesson, 1832, possibly *Iasis zonaria*.

S. quadrata Herdman, 1888, seems to be an embryo of *Pegea confederata*.

S. rhomboides Quoy and Gaimard, 1824 (*rhomboidalis* Meyen, 1832) can not be identified, apparently not a salpa.

S. rubrolineata Lesson, 1832, can not be identified.

S. sipho Forskål, 1775, not a salpa.

S. socia Bosc, 1802, is said by Traustedt (1885) to be *Pegea confederata*, but the identification seems to me very doubtful.

S. solitaria Forskål, 1775, not a salpa.

S. suborbicularis Quoy and Gaimard, 1824, not a salpa.

S. triangularis Quoy and Gaimard, 1824, apparently not a salpa.

S. tricuspida Lesson, 1832, apparently *Iasis zonaria*, solitary.

S. tricuspidata Quoy and Gaimard, 1824, can not be identified.

S. tricuspidata Sars, 1829, is said by Traustedt (1885) to be *S. fusiformis*. I have not succeeded in finding in this country this paper of Sars.

S. vaginata Chamisso, 1819, can not be identified with certainty; it may be *S. fusiformis*, subspecies *aspera*, solitary form.

Thalia lingulata Blumenbach, 1910. Traustedt regards this as *Thalia democratica*. The identification seems probable.

GENERIC AND SUBGENERIC NAMES.

The following list shows the first use of the several generic and subgeneric names applied to Salpidae:

Apsteinia, Metcalf, in this paper.
Biphora Bruguiere, 1789.
Brooksia, Metcalf, in this paper.
Cyclosalpa de Blainville, 1827.
Dagysa Banks and Solander, 1773.
Dubreuillia Lesson, 1832.
Holothuria Linneus, 1758.
Holothurium Pallas, 1774.
Iasis Savigny, 1816.
Pegea Savigny, 1816.
Pyrosomopsis [=*Cyclosalpa*] MacDonald, 1863.
Ritteria Metcalf, in this paper.
Salpa Forskål, 1775.
Thalia Browne, 1756.
Thetys Tilesius, 1802.
Traustedtia Metcalf, in this paper.
Pterolyra Lesson, 1832, is not a salpa.

KEY TO THE SUBGENERA AND SPECIES OF SALPIDAE.

A. Intestine in the solitary forms a straight tube dorsal to the gill. In the aggregated zoöids it is either a straight tube or is bent into an open loop.
Dolichodaea. One genus, *Cyclosalpa*.

a, 1 Aggregated zoöids bilaterally symmetrical. Terminal zoöids of stolon detached in the form of a whorl. *Cyclosalpae symmetricales*.

α, *1* Luminous organs 5 pairs in solitary form, 1 pair in aggregated form; body muscles in solitary form all interrupted dorsally: intestine in aggregated zoöid a straight tube below the endostyle. (type[1]) *pinnata*.

α, *2* Luminous organs wanting in both solitary and aggregated forms: posterior 5 body muscles in solitary forms complete dorsally: intestine in aggregated zoöid an open vertical loop in the median plane, anus in front of esophageal aperture. *affinis*.

α, *3* Luminous organs in solitary form 5 pairs, the first and last slightly developed or almost wanting; luminous organs altogether absent in aggregated zoöids; caeca, 2 in solitary form, 1 in aggregated form, globular; body muscles in solitary form all interrupted dorsally; testis in the aggregated zoöid occupying a large conical postabdomen within a swollen mass of test. *floridana*.

The author prefers the latin form *typus* in strictly taxonomic use of this word.

a, 2 Aggregated zoöids bilaterally asymmetrical, terminal zoöids of stolon not known to be detached in whorls................*Cyclosalpae asymmetricales.*

α, 1 Body muscles in solitary form not forming any ventral horizontal bands: postabdomen of aggregated zoöid long and unequally bifurcate, the larger division occupied by the intestine proximally and the slender testis distally, the smaller division occupied proximally by the single caecum and distally by a cell mass superficially resembling the testis. *bakeri.*

α, 2 Certain of the body muscles of the solitary form elongated to form a dorsal and a ventral pair of horizontal bands: aggregated zoöid with undivided postabdomen containing intestine and testis..................*virgula.*

B. Gut in solitary forms not making a very compact nucleus. The course of the intestine can be traced without dissection. In the aggregated zoöids the gut forms a "nucleus" in which, in most species, the course of the intestine can hardly be detected by superficial observation.

CIRCODEA.

b, 1 Solitary form with a long anterior protuberance below the mouth, containing wide muscle bands. Aggregated zoöids very asymmetrical..*Brooksia.*

β, 1 One species..*rostrata.*

b, 2 Body muscles in the solitary form more than 10, asymmetrically continuous across the dorsal mid line............................*Ritteria.*

β, 1 Body muscles 15: aggregated zoöids inadequately known, asymmetrical..*retracta.*

β, 2 Body muscles in the solitary form 21 or more: aggregated zoöids unknown...*picteti.*

β, 3 Body muscles in the solitary form 11, not so wide as to form an almost continuous layer; gut a transverse vertical loop: aggregated zoöid asymmetrical, its gut a close loop but with the course of the intestine visible............................(type) *amboinensis.*

β, 4 Body muscles in the solitary form very broad forming an almost continuous layer, especially posteriorly; a pair of postero-lateral appendages present: aggregated zoöid showing 6 well-marked longitudinal ridges; it has 6 broad body muscles........*hexagona.*

b, 3 Solitary form with 5 pairs of very broad muscle bands and a narrower shorter 6th on the dorsal surface behind them, body terminating behind in a sharp point whose enlarged base contains the gut; atrial aperture a horizontal slit. Aggregated zoöid with similar atrial aperture, 3–5 embryos, 5 strong body muscles, nearly parallel, all but the first continuous across the mid-dorsal line, body pointed behind and narrowing to a truncated point in front............................*Iasis.*

β, 1 One species..*zonaria.*

b, 4 Solitary form with a pair of well-developed postero-lateral appendages.

bb, 1 Atrial siphon in both solitary and aggregated forms tubular; body muscles in both forms confined to the dorsal half of the body, numerous in the solitary form, most of them interrupted both dorsally and laterally; body muscles 5 in aggregated zoöid.....*Ihlea.*

β. 1 One species...................................*vagina.*

bb, 2 Atrial aperature in both solitary and aggregated forms a slit...*Thalia.*

β, 1 Appendages in solitary form about as long as body, body muscles nearly parallel, interrupted ventrally. Body muscles of aggregated zoöid with from 5–11 fibers each....................................*longicauda* *β, 2* Appendages in solitary form less than half as long as the body, body muscles forming complete uninterrupted loops: body muscles in aggregated zoöid with from 3–5 fibers each ....(type) *democratica.*

b, 5 Body muscles in both solitary and aggregated forms 4, confined to the dorsal half of the body, forming an anterior and a posterior X-shaped group...*Pegea.*

β, 1 Aggregated zoöid with a pair of postero-lateral appendages, usually of unequal length, eye somewhat stalked.
confederata, subspecies *bicaudata*

β, 2 Without the characteristics specified under *β*, 1....*confederata.*

b, 6 Solitary form with numerous tubular appendages from different parts of the body...*Traustedtia.*

bb, 1 Appendages in solitary form 20 or more, gut forming a horizontal spindle-shaped mass: aggregated zoöid probably not known.
radiata.

bb, 2 Appendages in solitary form not more than 13, gut forming a vertical spindle-shaped mass. Aggregated form with a single unequal pair of postero-lateral appendages.

β, 1 Appendages of the solitary form 8, the posterior pair about as long as the body. Oral muscles continuous across the mid-dorsal line.................(type) *multitentaculata.*

β, 2 Appendages of the solitary form 13. Oral muscles very short dorsally, hardly extending above the angles of the mouth...........*multitentaculata*, subspecies *bicristata.*

C. Gut in both solitary and aggregated forms making a compact "nucleus," in which the course of the intestine can not be clearly seen without dissection.
SPHAERODAEA.

c, 1 Body muscles in solitary form widely interrupted ventrally: aggregated zoöids asymmetrically more or less pointed in front and behind, body muscles not very asymmetrical..................................*Salpa.*

cc, 1 Body muscles in solitary form all about parallel. Gut nucleus in aggregated zoöid on mid-line, pushing the posterior protuberance to one side; body muscles IV and V not in contact laterally.

κ, 1 Anterior and posterior appendages in aggregated zoöid about $\frac{1}{4}$ as long as body, no swollen spinose areas at base of atrial siphon......................*maxima.*

κ, 2 Anterior and posterior appendages in aggregated zoöid about $\frac{1}{2}$ as long as body, 2 unequal spinose thickenings of the test dorsally near the base of the atrial siphon.
maxima, variety *tuberculata.*

cc, 2. Body muscles I to III in the solitary form in contact dorsally, the rest parallel; body muscles IV and V in the aggregated zooid in contact laterally.

κ, 1. Neither solitary nor aggregated forms bearing spinose ridges................................(type) *fusiformis.*

κ, 2. Both solitary and aggregated forms bearing spinose ridges.
fusiformis, form *aspera.*

cc, 3. Body muscles I to IV in the solitary form in contact dorsally. In aggregated zooid body muscles I to III and IV and V are fused dorsally to form 2 broad bands. These 2 bands are in contact dorsally and may be united.........................*cyclindrica.*

- *cc, 2.* Body muscles in solitary form complete uninterrupted loops; in aggregated form decidedly asymmetrical.................. *Apsteinia.*
  - *κ, 1.* Body muscles 7 in solitary form, 5 in aggregated form, continuous in both forms across mid-dorsal and mid-ventral lines; oral retractor muscle not continued far backward as 2 horizontal bands on each side..................... *maghalanica.*
  - *κ, 2.* Oral retractor muscles in solitary form continued far backward as two horizontal bands on each side, the dorsal one much the longer; body muscles in aggregated form interrupted ventrally.
    - *κκ, 1.* In solitary form lips and postero-ventral region near gut bearing many fine branching lines of pigment; aggregated zoöid punctate with pigment spots along mid-ventral line...........(type) *punctata.*
    - *κκ, 2.* No pigmented lines or spots on lips or mid-ventral area in either form................. *asymmetrica.*

LITERATURE CITED.

Apstein, 1894, *a.* Die Salpen der Berliner zoologischen Sammlung. Arch. Naturg., vol. 60, pt. 1, p. 1.

——— 1894, *b.* Die Thaliacea der Plankton-Expedition. B. Vertheilung der Salpen. Ergeb. der Plankton-Exped. der Humboldt-Stiftung. By V. A. C. Hensen. Vol. 2. Kiel and Leipzig.

——— 1901. Nordisches Plankton. Lief. 1.

——— 1904. Salpes d'Amboine. Rev. Suisse de Zool. Vol. 12, f. 3.

——— 1906, *a.* Die Salpen der deutschen Südpolar-Expedition. Deutsche Südpol.-Expedit. 1901–1903, vol. 9, Zool. 1. Berlin.

——— 1906, *b.* Salpen der deutschen Tiefsee-Expedition. Wiss. Ergebnisse der Deutsch. Tiefs.-Expedit. 1898–99, vol. 12. Jena.

Banks, 1814. (In) Home, Lectures on Comparative Anatomy. Vol. 2, pls. 71–74. London.

Banks and Solander, 1773. Hawkesworth's Voyages, vol. 2, pp. 2–3.

de Blainville, 1827. Salpa. Dictionnaire des sciences naturelles. Vol. 47. Strasbourg and Paris.

Blumenbach, 1810. Abbildungen naturhistorischer Gegenstände. No. 30. Göttingen.

Bory de St. Vincent, 1804. Voyage aux quatre îles d'Afrique. Vol. 1. Paris and Liege.

Bosc, 1802. Histoire naturelle des Vers. Vol. 2. Paris.

Brooks, 1886. The Anatomy and Development of the Salpa-Chain. Studies from the Biol. Lab. of the Johns Hopkins Univ. III.

——— 1893. The genus Salpa. With a supplementary paper by Maynard M. Metcalf. Mem. Johns Hopkins Univ. II.

——— 1908. The Pelagic Tunicata of the Gulf Stream. II. Salpa floridana. Publ. Carnegie Institution, 102. Washington.

Browne, Patrick, 1756. The Civil and Natural History of Jamaica. London.

Bruguière, 1789. Histoire nat. des Vers, etc., Encyclopédie Méthodique. Vol. 1. Paris.

Chamisso, 1819. De animalibus quibusdam e classe Vermium Linnaeana. 1815–1818. Fasc. I. De Salpa. Berolini.

Costa, date uncertain. Fauna del Regno di Napoli, Animali molli. Ordine II, Acefali senza conchiglia.

Cuvier, 1804. Mémoire sur les Thalides (Thalia, Browne) et sur les Biphores (Salpa Forskål). Ann. Mus. Hist. Nat. Vol. 4.

——— 1817. Le Règne Animal distribué d'après son Organisation. Vol. 2. Paris.

CUVIER, 1828. Le Règne Animal. édit. accompagnée de Pl. gravées; les Mollusques avec un Atlas, par M. G. P. Deshayes. Paris.

DALL, 1872. Descriptions of 60 new forms of mollusks from the west coast of North America and the north Pacific Ocean. Amer. Journ. Conchol. Vol. 7.

DELAGE and HÉROUARD, 1898. Traité de Zoologie concrète, vol. 8. Les Procordés.

DELLE CHIAJE, 1828. Memorie sulla storia e notomia degli Animali senza vertebre del regno di Napoli. Vol. 3. Napoli.

———, 1841. Descrizione e notomia degli Animali invertebrati della Sicilia citeriore osservati vivi negli anni 1822–1830. Vol. 3. Napoli.

DESOR, 1851. [*Salpa Caboti*, sp. n., exhibited and described.] Proc. Boston Soc. Nat. Hist., vol. 3.

DOBER, 1912. Beiträge zur Kenntnis des Nervensystems der Salpen. Inaugural-Dissertation. Leipzig.

FLEMING, 1842. A History of British Animals. Edinburgh.

FORSKÅL, 1775. Descriptiones animalum, etc., quae in itinere orientali observavit. Hafniae.

FOWLER, 1896. Contributions to our knowledge of the Plankton of the Faeroë Channel, No. 1. Proc. Zool. Soc. Lond.

GMELIN, 1791. Linnaeus' Systema Naturae, ed. 13., vol. 3. Lipsiae.

GÖPPERT, 1892. Untersuchungen über das Sehorgan der Salpen. Morphol. Jahrb. Vol. 19. Heft 2.

HEIDER, 1895. Beiträge zur Embryologie von Salpa fusiformis, Cuv. Abh. Senckenb nat. Ges., vol. 18, p. 4. Frankfurt.

HERDMAN, 1888. Report upon the Tunicata collected during the voyage of H. M. S. Challenger, during the years 1873–1876. III. Ascidiae Salpiformes. Zool. Challenger Exped., vol. 27. London.

——— 1891. A Revised Classification of the Tunicata, with definitions of the orders suborders, families, subfamilies, and genera, and analytical keys to the species. Jour. Linn. Soc. Lond., Zool., vol. 23.

——— 1904. Ascidians and Amphioxus. Cambridge Natural History, vol. 7.

HOME, 1814–1828. Lectures on Comparative Anatomy.

HOPKINSON, 1913. A Bibliography of the Tunicata. London. Ray Society.

IHLE, 1910. Die Thaliaceen (einschliesslich Pyrosomen) der Siboga-Expedition. Siboga-Expeditie, Monogr. 56*d*. Leiden.

———, 1911. Über die Nomenklatur der Salpen. Zool. Anzeiger, vol. 38, no. 25/26.

JULIN, CH., 1912. Les caractèrs histologiques specifiques des "cellules lumineuses" de *Pyzosoma giganteum* et de *Cyclosalpa pinnata*. Comptes rendus, Acad. Sci. Paris, vol. 155, 1912,

KROHN, 1846. Observations sur la génération et le développement des Biphores Salpa. Ann. Sci. Nat. (3). vol. 6.

LAMARCK, 1813. Sur les Polypiers empâtés. Ann. Mus. Hist. Nat., vol. 20.

——— 1816. Histoire naturelle des animaux sans vertèbres. vol. 3. Paris.

LESSON, 1830. Centuries Zoologiques. Paris.

———, 1832. Voyage autour du monde, éxecuté par ordre du roi, sur la corvette de S. M. "La Coquille" pendant les années 1822–25. Par L. I. Duperrey. Zoologie. vol. 2. Paris.

LINNAEUS, 1758. Systema naturae, ed. 10. vol. 1. Holmiae.

——— 1788–91. Systema Naturae, ed. 13. Gmelin. London.

MACCULLOCH, 1819. A description of the Western Islands of Scotland including the Isle of Man. vol. 2. London.

MACDONALD, J. D., 1862. On a new genus of Tunicata occurring on one of the Bellona Reefs. Journ. Linn. Soc. Lond., Zool., vol. 6.

———, 1864. On the Relationship of the Fixed and Free Tunicata, etc. Transactions of the Royal Society of Edinburgh, vol. 23.

Metcalf, 1892. The Anatomy and Development of the Eyes and Subneural Gland in *Salpa.* Johns Hopkins Univ. Circ. XI.

———, 1893, *a.* Notes upon an apparently new species of *Octacnemus*, a deep-sea, Salpa-like Tunicate. Johns Hopkins Univ. Circ. XII.

———, 1893, *b.* On the Eyes, subneural Gland, and central Nervous System in Salpa. Zool. Anzeig., no. 409.

——— 1893, *c.* The Eyes and subneural Gland of Salpa. Memoirs from the Biological Laboratory of the Johns Hopkins University. II.

———, 1897. The Neural Gland in *Ascidia atra.* Zool. Bulletin, vol. 1, No. 3.

———, 1899. An Answer to a Suggestion by Delage and Hérouard that the Accessory Eyes in Salpidae may be Otocysts. Anat. Anzeig., vol. 16.

——— 1900. Notes on the Morphology of the Tunicata. Zool. Jahrb., Anat., vol. 13.

——— and Johnson, 1905. The Anatomy of the Eyes and neural Glands in the aggregated forms of *Cyclosalpa dolichosoma virgula* and *Salpa punctata.* Biol. Bull., vol. 9.

——— and Hopkins, 1919. Pyrosoma, a Taxonomic Study. Bulletin 100, vol. 2, Part 3, U. S. National Museum.

Meyen, 1832. Beiträge zur Zoologie, gesammelt auf einer Reise um die Erde. Nova Acta Akad. Leop.-Car., vol. 16, p. 1.

Milne-Edwards, 1828. Recherches aux iles Chausey (1828). Ann. Sci. Nat., vol. 15.

Oka, 1912. Eine neue phylogenetisch interessante Synascidia (*Cyathocormus mirabilis*, n. g., n. sp.). Zool. Anzeig., vol. 11, 10/11, Oct., 1912.

———, 1913. On Cyathocormus mirabilis, nov. gen., nov. sp., the Type of a New Family of Compound Ascidians from Japan. Journ. of Coll. of Science, Imperial Univ. of Tokyo, vol. 32, art. 12.

Otto, 1823. Beschreibung einiger neuen Mollusken und Zoophyten. Nova Acta Akad. Leop. -Car., vol. 11, p. 2. Bonnae.

Pallas, 1774. Specilegia zoologica. Fasc. X. Berolini.

Peron and Lesueur, 1807. Voyage de découvertes aux Terres Australes, 1800–1804. vol. 1. Paris.

Quoy and Gaimard, 1824. Voyage autour du monde . . . . 1817–1820. Par M. Louis de Freycinet. Zoologie. Paris.

———, 1826. Sur quelques pointes de l'organisation des Biphores. Nouv. Bull. Soc. philom. Anne, 1826.

——— 1826–34. Voyage de la corvette l'Astrolabe, éxecuté par l'ordre du roi, etc. Zoologie.

———, 1827. Observations zoologiques faites à bord de l'Astrolabe en Mai 1826, dans le détroit de Gibraltar. Ann. Sci. Nat. (1), vol. 10.

Redikorzeff, 1905. Über das Sehorgan der Salpen. Morphol. Jahrb., vol. 34. Heft 2.

Ritter, 1905. The Pelagic Tunicata of the San Diego Region excepting the Larvacea. Univ. Calif. publ., Zool., vol. 2, p. 3.

——— 1906, *a.* Octacnemus. (In) Reports on the scientific results of the expedition to the Eastern Tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross," from October, 1904, to March, 1905. Bull. Mus. Comp. Zool., vol. 46.

——— 1906, *b.* Cyclosalpa retracta, a new Salpoid from the coast of Japan. Annot. Zool. Japan, vol. 6, p. 1.

——— and Johnson, 1911. The Growth and Differentiation of the Chain of Cyclosalpa Affinis, Chamisso. Journ. of Morphol., vol. 22, no. 2.

Sars, Michael, 1829. Bidrag til Söedyrenes Naturhistorie. Bergen.

Savigny, 1816. Mémoires sur les Animaux sans Vertèbres, vol. 2, fasc. I. Paris.

Sigl, M. Aquina, 1912, *a.* Cyclosalpa polae, n. sp. aus dem östlichen mittelmeer. Zool. Anzeiger, vol. 39, no. 2.

SIGL, 1912, *b*. Die Thaliceen u. Pyrosomen des Mittelmeers u. der Adria., etc., in Denkschriften der k. Akad. der Wissenschaften. vol. 88.

STREIFF, 1908. Über die Muskulatur der Salpen und ihre systematische Bedeutung. Zool. Jahrb., vol. 27, no. 1.

TILESIUS, 1802. Abbildung und Beschreibung eines sonderbaren Seebeutels oder einer neuen Thetys-Species aus dem Atlant. Ocean, Thetys vagina. Jahrbuch der Naturgeschichte, vol. 1.

TODARO, 1883. Sopra una nuova forma di *Salpa* (*S. dolicosoma*). Atti Accad. Lincei (3), vol. 8. Roma.

TRAUSTEDT, 1885. Spolia Atlantica. Bidrag til Kundskab om Salperna. Danske Vid. Selsk. Skrift. (6), vol. 2 (1886).

——— 1893. Die Thaliacea der Plankton-Expedition. A. Systematische Bearbeitung. Ergebn. der Plankt.-Exped. der Humboldt-Stiftung. II. Kiel and Leipzig.

VOGT, 1854. Recherches sur les animaux inférieurs de la Méditerranée. II. Sur les Tuniciers nageants de la mer de Nice. Mém. Inst. Genèv., vol. 2, p. 3.

This manuscript was completed for the United States Bureau of Fisheries on July 10, 1915, and received for publication by the United States National Museum on February 21, 1917.

EXPLANATION OF TEXT FIGURES AND PLATES.

Interpretation of index letters, numbers, and signs. These are the same in text figures and plates.

The ball is dorsal, the pointed end of the rod is ventral.

⟶ The arrow points anteriorly.

The previous two signs combined.

The endostyle in the text figures is generally shown in solid black, the peripharyngeal band as a dashed line.

a=lateral portion of the dorsal eye in *Salpa cylindrica*.
an.=anus.
a. o.=atrial opening.
a. r.=atrial retractor.
a. s.=atrial sphincter. The atrial sphincters are often numbered *a. s. 1*; *a. s. 2*, etc.
a. v.=antero-ventral prolongation of ganglion.
b=small-celled outgrowth from the ganglion.
b′=large-celled outgrowth from the ganglion.
b. c.=blood corpuscle.
b. s.=blood sinus.
c.=caecum.
c′.=caecum of right side.
c″.=caecum of left side.
c. f.=ciliated funnel, dorsal tubercle.
cl.=cloaca.
cl. ep.=cloacal epithelium.
cl. s.=cloacal siphon.
d.=duct of neural gland.
d. l.=dorsal lamina.
d. m. l.=dorsal mid line.
d. o.=aperture of duct of neural gland into the pharyngeo-atrial chamber.
dor.=dorsal.
e.=eye, usually meaning the dorsal eye.

e.1, *e.2*, *e.3*, etc.=parts of dorsal eye labeled with no indication of homologies.
e′.=basal portion of dorsal eye.
e′′.=apical portion of dorsal eye.
e′′′.=optic plug of *Cyclosalpa pinnata* or its homolog in other species.
ech.=spinose area of the test in *Salpa maxima*, variety *tuberculata.*
el.=eleoblast.
em.=embryo.
en.=endostyle.
ep.=ectodermal epithelium.
eq=accessory eye or accessory portion of eye in solitary form.
ex=accessory eye in ganglion, dorsal.
ey=accessory eye in ganglion, posterior, anterior, or lateral.
g.=gill.
gg=ganglion.
gl.=gland.
h.=heart.
h. m.=dorsal horizontal muscle.
I, *II*, *III*, etc.=body muscles.
i. c.=intermediate cells.
i. m.=intermediate muscle.
int.=intestine.
k=ectodermal epithelium.
k′=pharyngeal epithelium.
l.=oral sphincter muscle of lower lip. These are often numbered *l.1*, *l.2*, *l.3*, etc.
l. o.=luminous organ.
lu.=lumen of nerve tube.
m.=mouth.
n.=nerve.
n. c.=nerve cell in ganglion in zone of origin of the nerves.
n. x.=nerve to dorsal accessory eye in ganglion.
o.=ovary.
o. c.=optic chamber, a lymph space.
od.=oviduct.
oe.=esophagus or its aperture.
o. r.=oral retractor.
o. s.=optic sheath, of ectodermal epithelium.
p.=pigment.
p′.=pigment of basal portion of eye.
p′′.=pigment of apical portion of eye.
p′′′.=pigment of optic plug in *Cyclosalpa pinnata*, or its homolog in other species.
p. a.=post-abdomen.
pd.=peduncle.
ph.=pharynx.
ph. b.=peripharyngeal band of cilia.
ph. ep.=pharyngeal epithelium.
pl.=placenta.
p. x.=pigment of dorsal accessory eye in ganglion.
q=problematic organ (or cells) near intestine.
r=primitively mid-posterior point of the eye. Used only in figure 12.
st.=stolon. (In figs. 31–33, pp. 59 and 60, it indicates what Ihle calls the "stololoblast" or "eleoblast".)

stm.=stomach.
t.=testis.
test=test.
u.=oral sphincter muscle of upper lip; often numbered *u.1*, *u.2*, *u.3*, etc.
v.=dorsal visceral muscle.
v.'=ventral portion of dorsal visceral muscle.
v.''=ventral visceral muscle.
v. d.=vas deferens.
ven.=ventral.
v. l.=ventral languet.
v. m. l.=ventral mid line.
v. s.=ventral atrial sphincter, or ventral portion of atrial sphincter.
xx=brown muscle of oral siphon in *Iasis*.
z.=zone of large cells in the ganglion, from which the nerves arise.

PLATE 1.

Cyclosalpa pinnata.

FIG. 1.—Solitary form seen from the right side. ×, 2.
2.—Ventral view of the ciliated funnel (dorsal tubercle) and adjacent structures in the solitary form.
3.—Aggregated zooid, seen from the right side. ×, 3.
4.—Ventral view of the ciliated funnel and adjacent structures in the aggregated zooid.

PLATE 2.

Cyclosalpa pinnata.

FIG. 5.—Testis and adjacent structures. The endostyle is placed more dorsally than is normal so as to show the testis more clearly.
6.—An antero-dextro-dorsal view of the oral end of the solitary form.
7.—The ganglion and dorsal eye of the aggregated zooid seen from the right side.
8.—Dorsal view of the same structures, including also one neural gland and the ducts of both glands.

PLATE 3.

Cyclosalpa affinis.

FIG. 9.—Solitary form viewed from the left side. Natural size.
10.—Aggregated zooid, seen from the left side. Natural size.

PLATE 4.

FIG. 11.—*Cyclosalpa affinis*, aggregated form; ganglion and eye from right side.
12.—*Cyclosalpa affinis*, solitary and aggregated form, ciliated funnel and adjacent organs. Ventral view.
13.—*Cyclosalpa floridana*, solitary form, seen from the left side. ×, 9.
14.—*Cyclosalpa floridana*, outline drawing of the esophagus, caecum, and beginning of the intestine, from fig. 13.

PLATE 5.

Cyclosalpa floridana.

FIG. 15.—Aggregated zooid, seen from the left side. ×, 14.
16.—Solitary and aggregated forms, ciliated funnel and adjacent organs. Ventral view.

PLATE 6.

Cyclosalpa floridana, aggregated zooid.

FIG. 17.—Ventral view. ×, 14.
18.—Dorsal view. ×, 14.

PLATE 7.

Cyclosalpa bakeri, solitary form.

FIG. 19.—View from the left side. ×, 8.
20.—Ciliated funnel and adjacent structures. Ventral view.

PLATE 8.

Cyclosalpa bakeri, aggregated zooid.

FIG. 21.—Large zooid, seen from the right side. ×, 8.
22.—Small zooid, seen from the left side. ×, 25.

PLATE 9.

Cyclosalpa bakeri, aggregated zooid.

FIG. 23.—Young zooid, seen from the right side. ×, 25.
24.—Ciliated funnel and adjacent structures. Ventral view.

PLATE 10.

Cyclosalpa bakeri, aggregated zooid.

FIG. 25.—Older zooid, a more magnified dextro-dorsal view of the posterior end of the body.

PLATE 11.

Cyclosalpa virgula.

FIG. 26.—Solitary form, seen from the right side. One-half natural size.
27.—Solitary form, ciliated funnel and adjacent organs. Ventral view.
28.—Aggregated zooid, seen from the right side. ×, 4.

PLATE 12.

Cyclosalpa virgula, aggregated zooid.

FIG. 29.—A view from the left side. ×, 4.
30.—A ventral view. ×, 4.

PLATE 13.

Cyclosalpa virgula, aggregated zooid.

FIG. 31.—Ganglion, eye and neural glands, in dorsal view.
32.—Ciliated funnel and adjacent structures. Ventral view.
33.—A zooid in dorsal view. ×, 4.

PLATE 14.

Transtedtia multitentaculata, subspecies *bicristata*, solitary form.

FIG. 34.—Dorsal view. ×, 11.
35.—View from the right side. ×, 11.

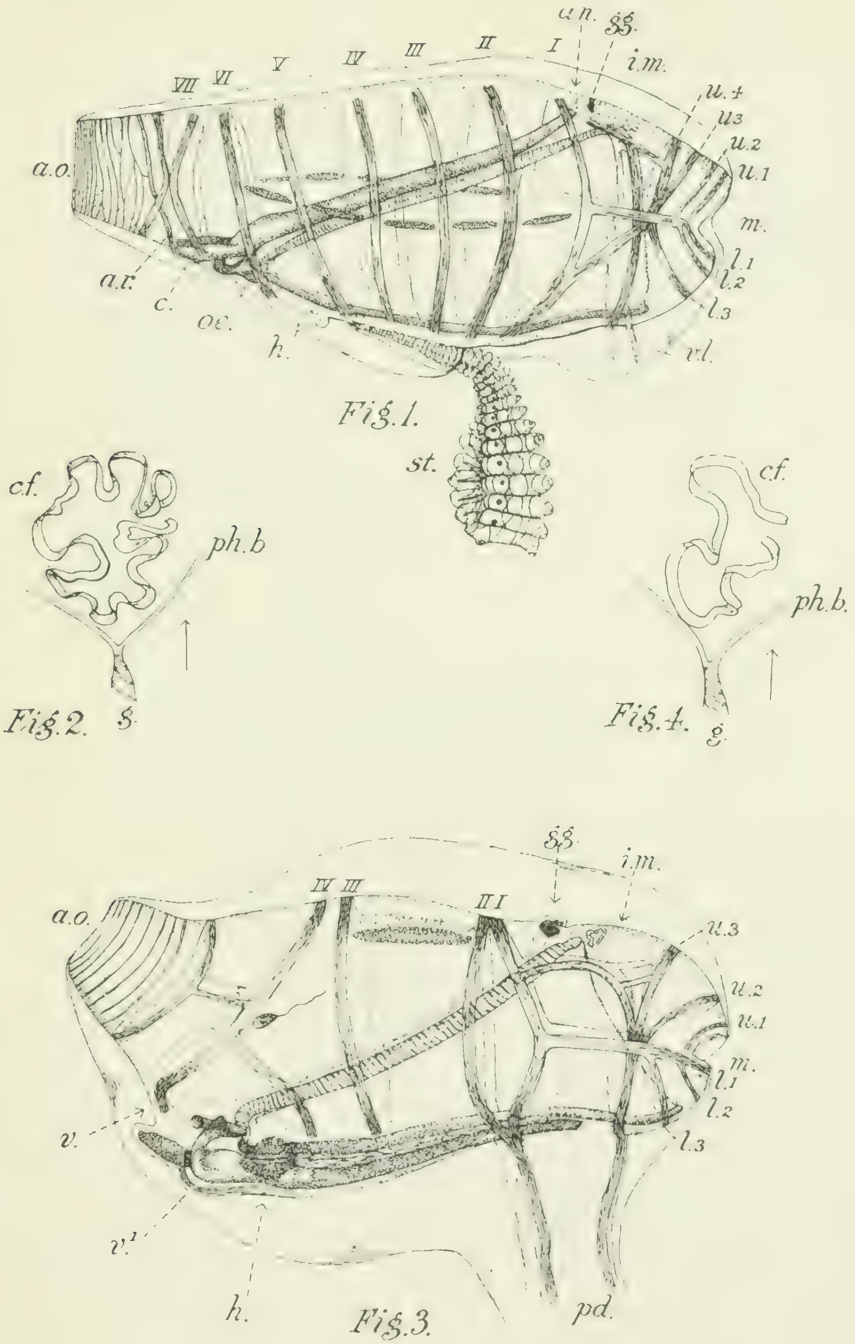

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Fig.3.
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Cyclosalpa pinnata. 1, Solitary Form, × 2; 2, Solitary Form, the Aperture of the Ciliated Funnel; 3, Aggregated form, × 3; 4, Aggregated Form. The Aperture of the Ciliated Funnel.

For explanation of plate see page 181.

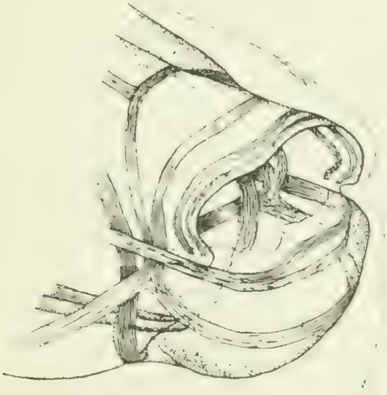
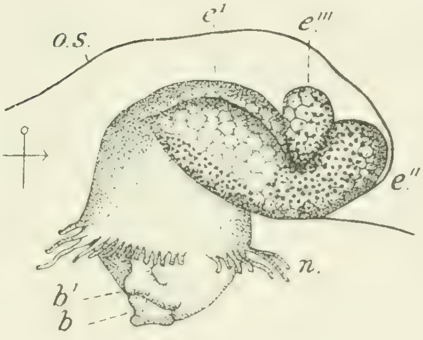


Fig. 6.



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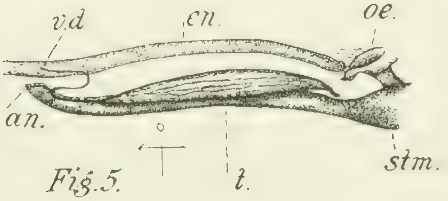

Fig. 5.

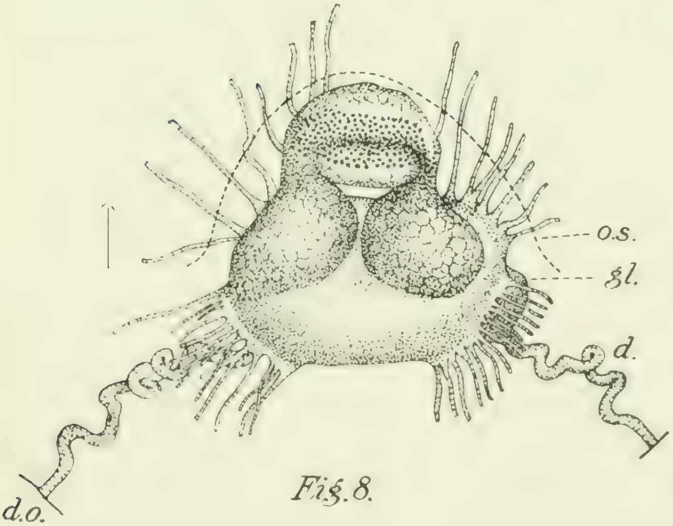

Fig. 8.

Cyclosalpa pinnata. 5, Aggregated Form, Testis, Part of the Gut, and the Endostyle; 6, Solitary Form, Oral Region; 7, Aggregated Form, Ganglion and Eye from the Right Side; 8, Aggregated Form, Ganglion and Eye from Above.

For explanation of plate see page 181.

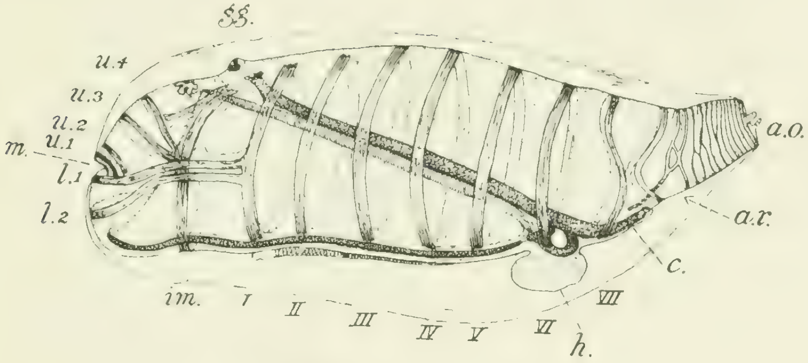
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Fig. 9.

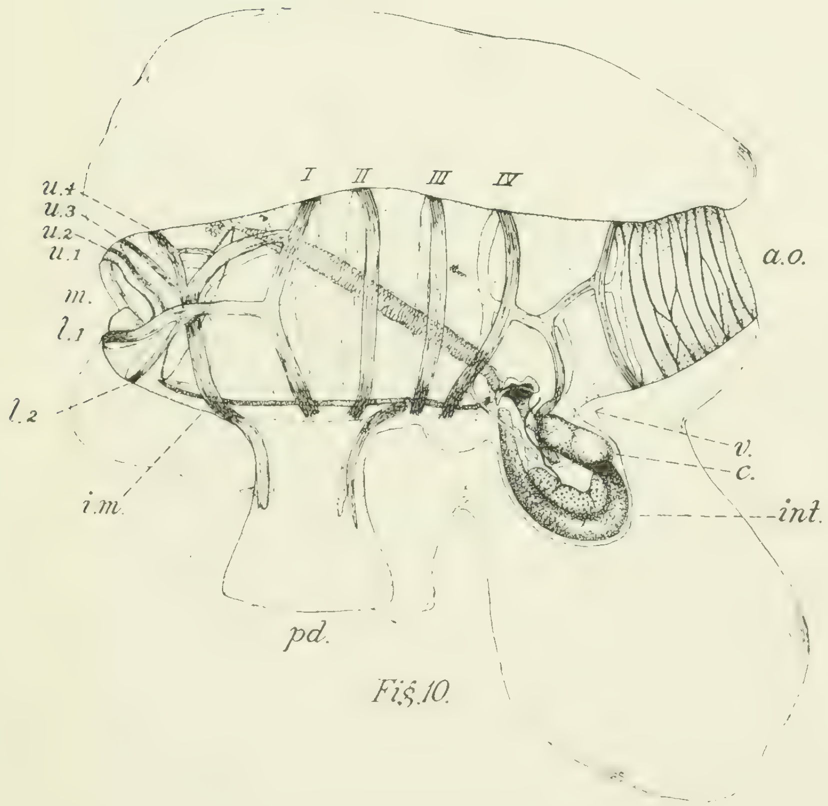
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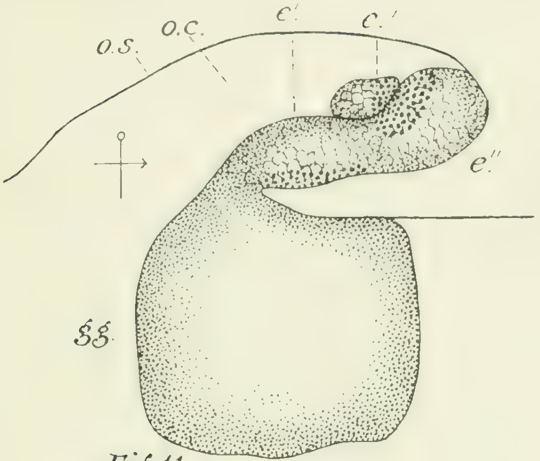
Fig. 10.

Cyclosalpa affinis. 9, Solitary Form, from Left Side, Natural Size; 10, Aggregated form, from Left Side, Natural Size.

For explanation of plate see page 181.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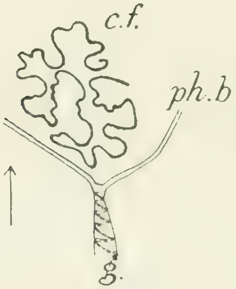

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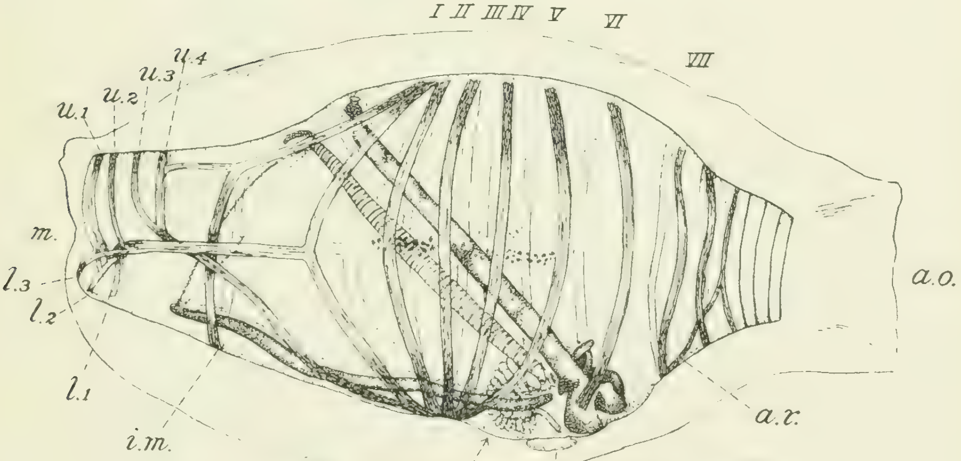
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Fig. 13.

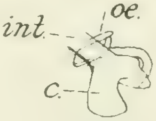

Fig. 14.

11, Cyclosalpa affinis, Aggregated Form, Ganglion and Eye from Right Side; 12, C. affinis, Aggregated Form, Aperture of Ciliated Funnel; 13, C. floridana, Solitary Form, from Left Side, × 9; 14, C. floridana, Solitary Form, the Gut Drawn in Outline.

For explanation of plate see page 181.

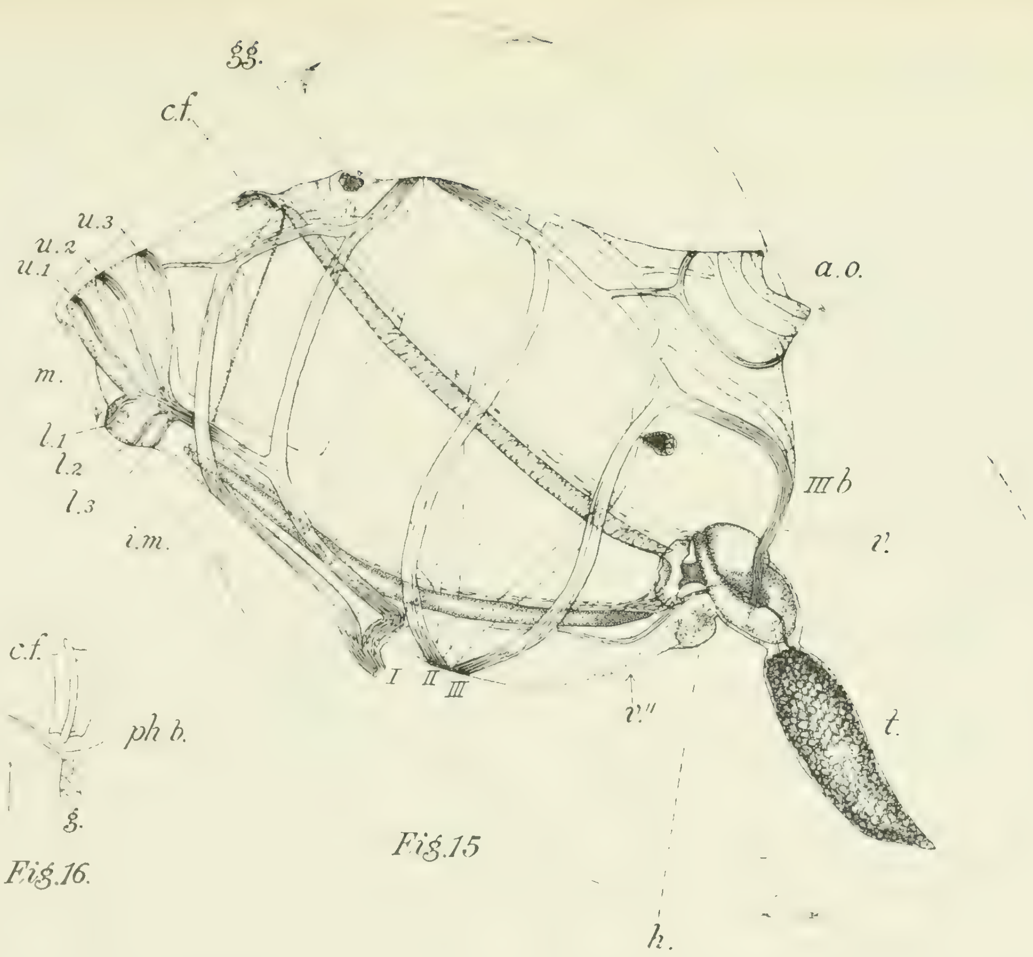
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Fig.15

Fig.16.

CYCLOSALPA FLORIDANA. 15, AGGREGATED ZOOID FROM LEFT SIDE, 14; 16, SOLITARY FORM, CILIATED FUNNEL.

FOR EXPLANATION OF PLATE SEE PAGE 181.

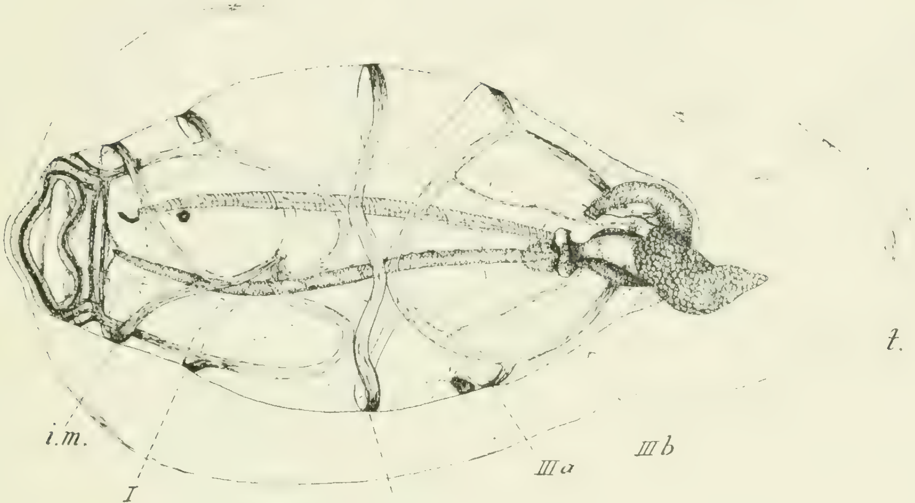
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Fig. 17.

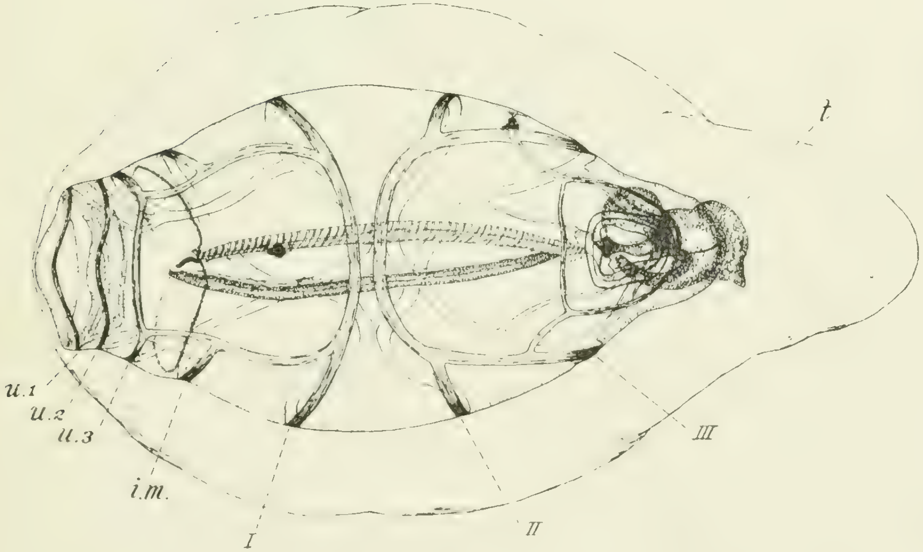
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Fig. 18.

CYCLOSALPA FLORIDANA. AGGREGATED ZOOID. 17, VENTRAL VIEW, × 12; 18, DORSAL VIEW, × 12.

FOR EXPLANATION OF PLATE SEE PAGE 182.

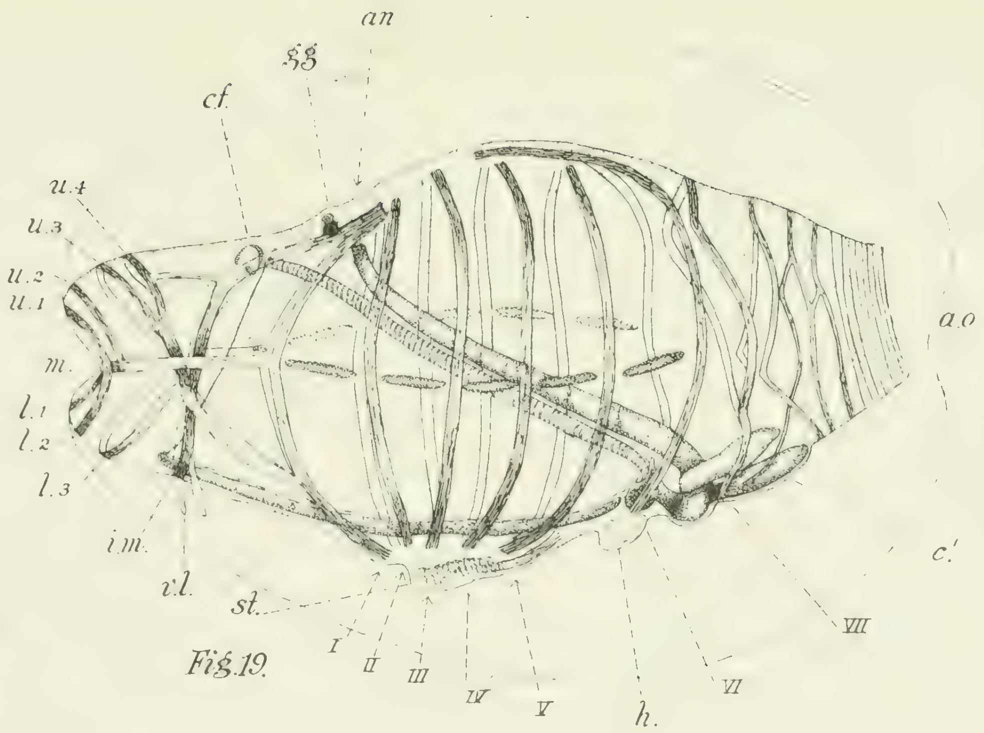
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Fig.19.

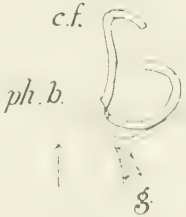

Fig.20.

CYCLOSALPA BAKERI. SOLITARY FORM. 19, VIEW FROM THE LEFT SIDE, 8; 20, CILIATED FUNNEL.

FOR EXPLANATION OF PLATE SEE PAGE 182

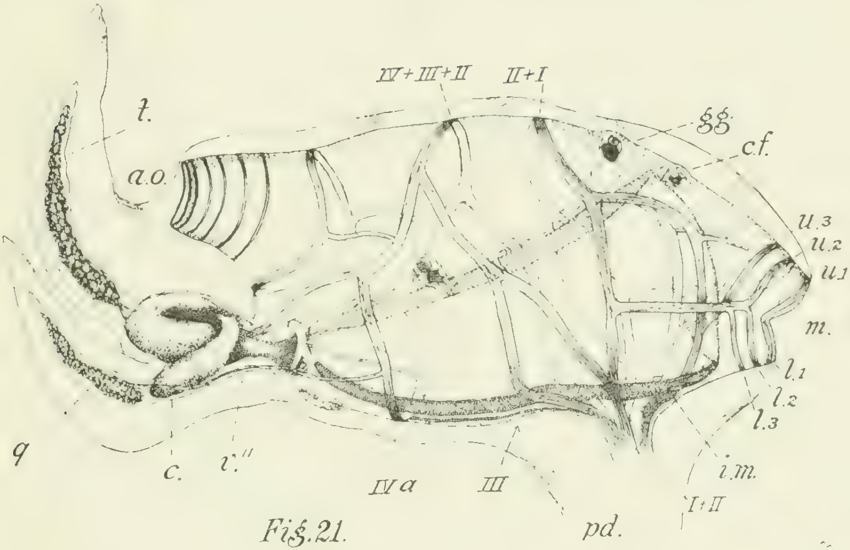
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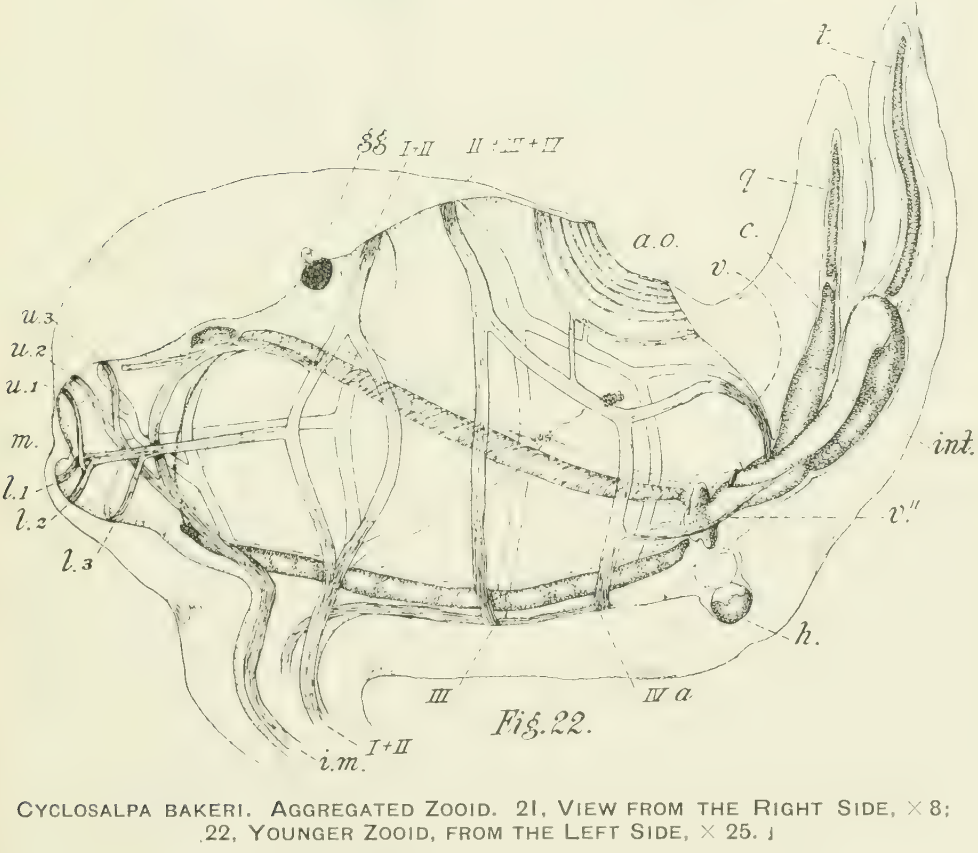
Fig. 21.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u.3
u.2
u.1
m.
l.1
l.2
l.3
int.
v.''
h.
III
IV a
I+II
i.m.

Fig. 22.

CYCLOSALPA BAKERI. AGGREGATED ZOOID. 21, VIEW FROM THE RIGHT SIDE, × 8; 22, YOUNGER ZOOID, FROM THE LEFT SIDE, × 25.

FOR EXPLANATION OF PLATE SEE PAGE 182.

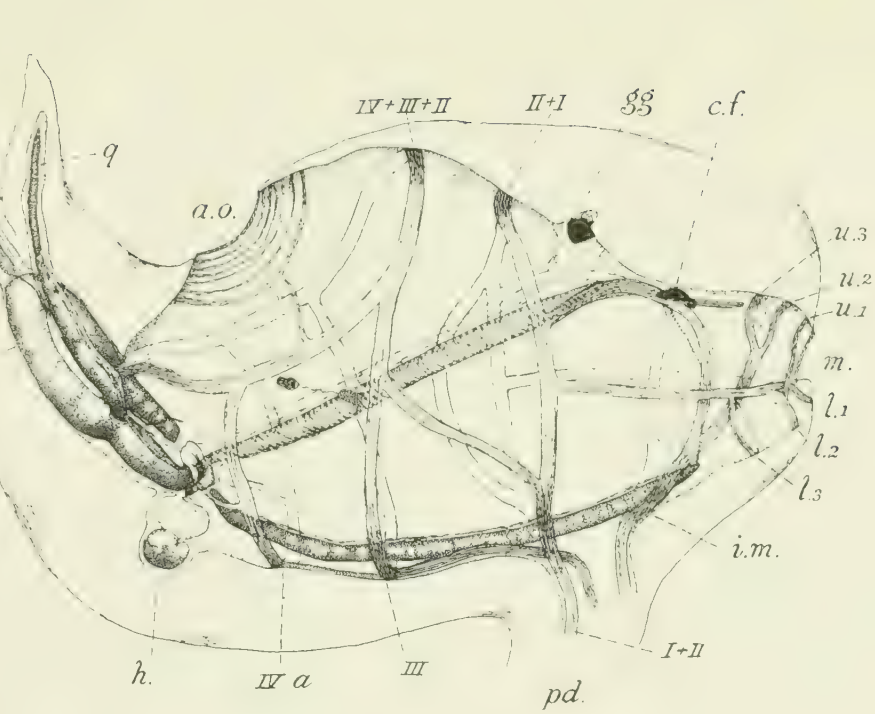

IV+III+II
II+I
gg
c.f.
t.
q
a.o.
u.3
u.2
u.1
m.
int.
l.1
l.2
l.3
i.m.
I+II
h.
IV a
III
pd.

Fig. 23.

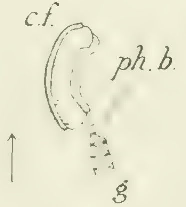


Fig. 24.

CYCLOSALPA BAKERI. AGGREGATED ZOOID. 23, YOUNG ZOOID VIEWED FROM THE RIGHT SIDE, × 25; 24, CILIATE FUNNEL.

FOR EXPLANATION OF PLATE SEE PAGE 182.

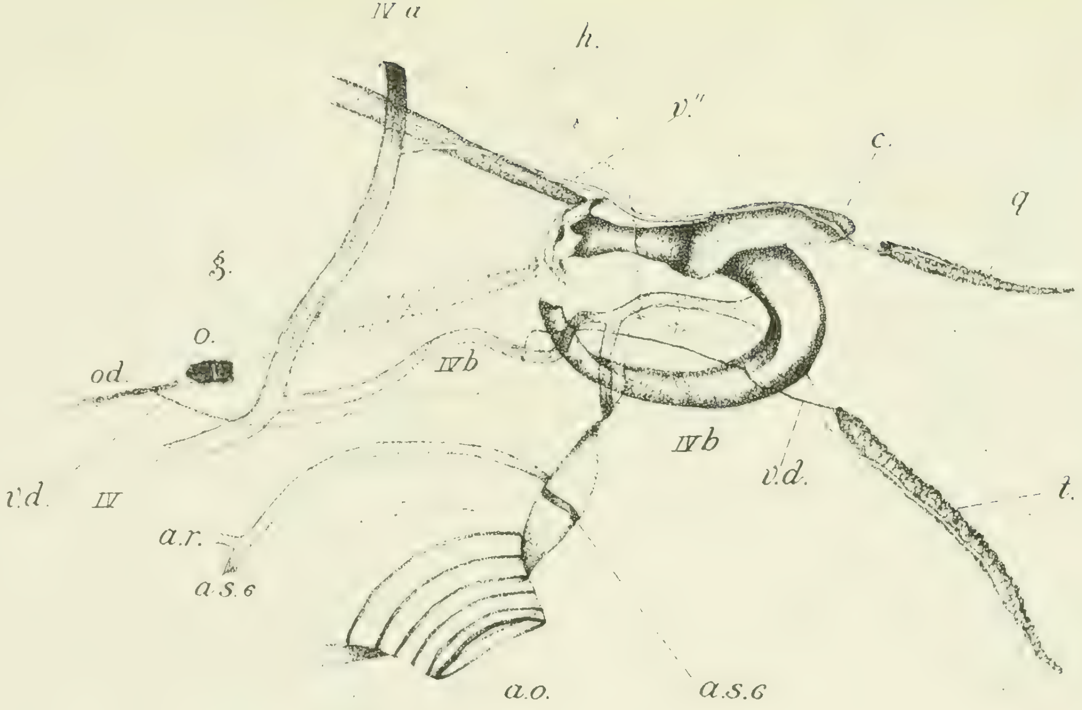

IV a
h.
v."
c.
q
g.
o.
od.
IV b
IV b
v.d.
t.
v.d.
IV
a.r.
a.s.6
a.o.
a.s.6

Fig. 25

CYCLOSALPA BAKERI. AGGREGATED ZOOID; POSTERIOR END, MORE HIGHLY MAGNIFIED, DEXTROVENTRAL VIEW.

FOR EXPLANATION OF PLATE SEE PAGE 182.

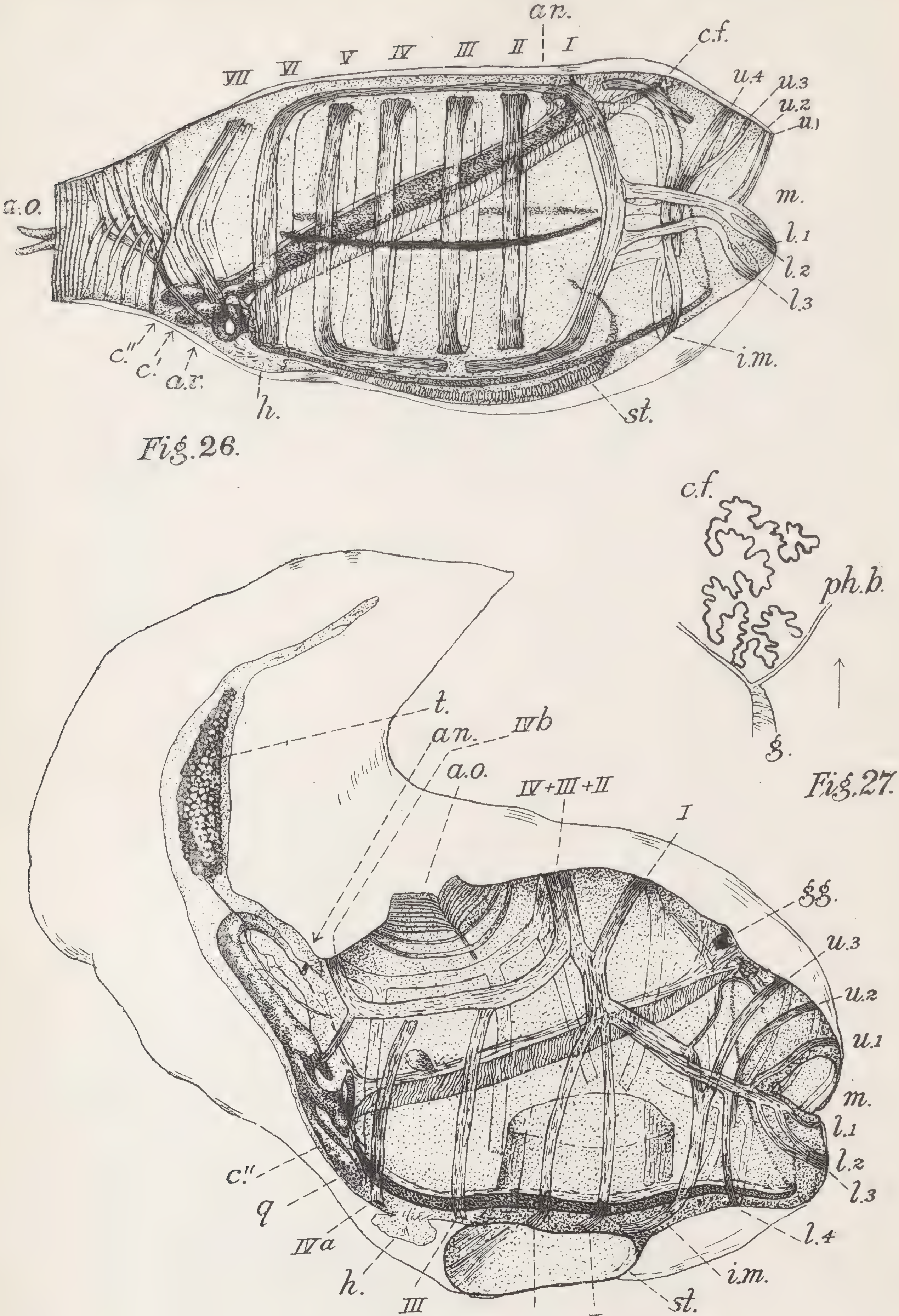

a.n.
VII
VI
V
IV
III
II
I
c.f.
u.4
u.3
u.2
u.1
a.o.
m.
l.1
l.2
l.3
c.''
c.'
a.r.
h.
st.
i.m.
c.f.
ph.b.
g.
t.
a.n.
IVb
a.o.
IV+III+II
I
g.g.
u.3
u.2
u.1
m.
l.1
l.2
l.3
l.4
c.''
q
IVa
h.
III
II
I
i.m.
st.

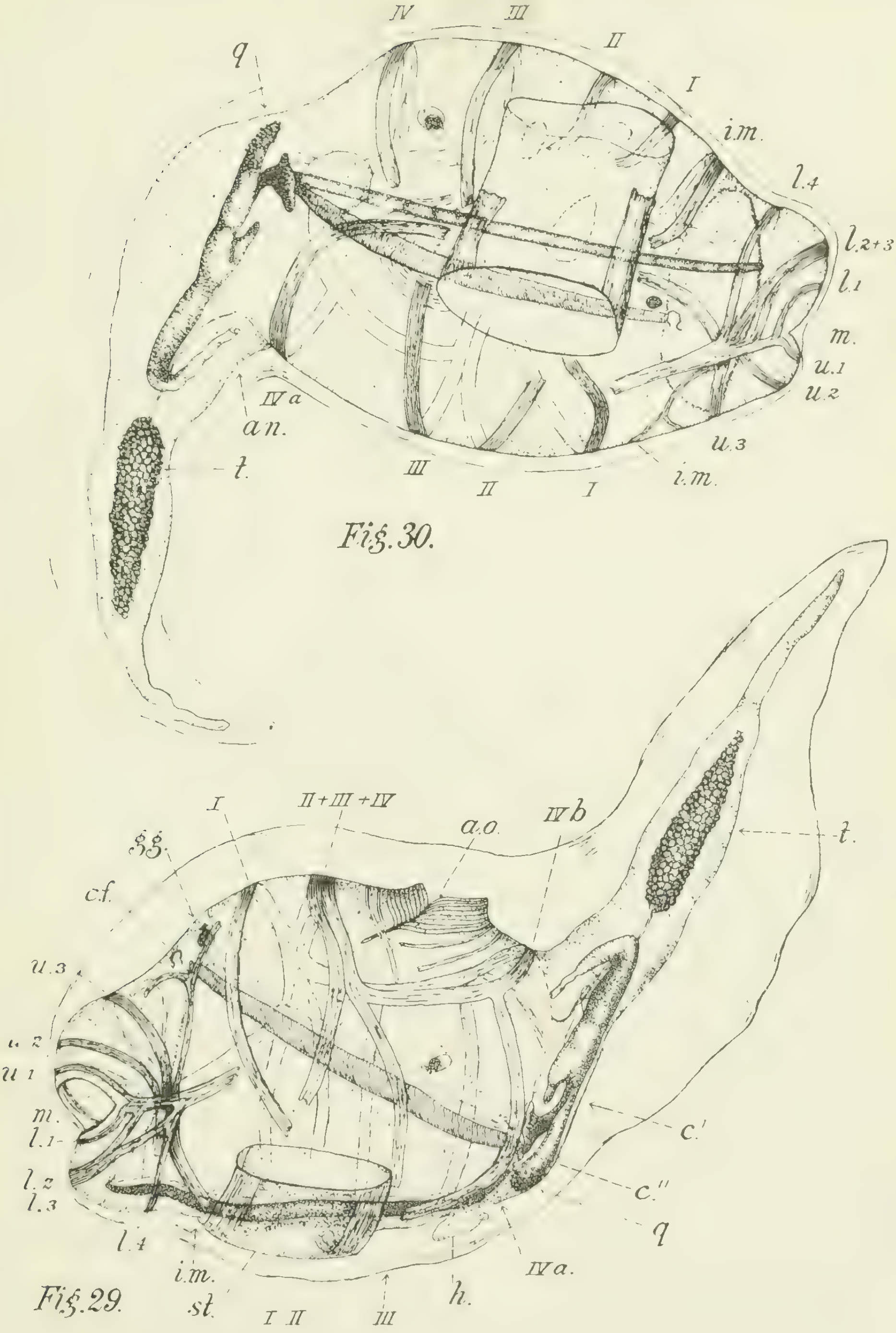
Fig. 26.

Fig. 27.

Fig. 28.

Cyclosalpa virgula. 26, Solitary Form, from Right Side, ½ Natural Size; 27, Solitary Form, Ciliated Funnel; 28, Aggregated Zooid, from Right Side, × 4.

For explanation of plate see page 182.


IV
III
II
I
q
i.m.
l.4
l.2+3
l.1
m.
u.1
u.2
IV a
an.
t.
u.3
III
II
I
i.m.
Fig. 30.
I
II+III+IV
a.o.
IV b
g.g.
c.f.
t.
u.3
u.2
u.1
m.
l.1
l.2
l.3
c.'
c.''
q
l.4
i.m.
IV a.
st.
I II
III
h.
Fig. 29.

Cyclosalpa virgula. Aggregated Zooid. 29, from Left Side, × 4; 30, Ventral View, × 4.

For explanation of plate see page 182

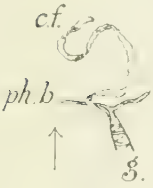


Fig. 32.

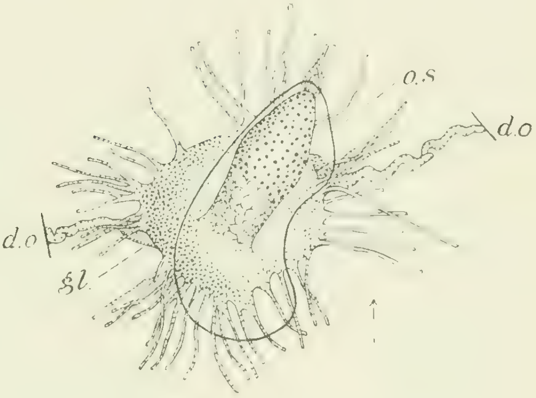


Fig. 31.

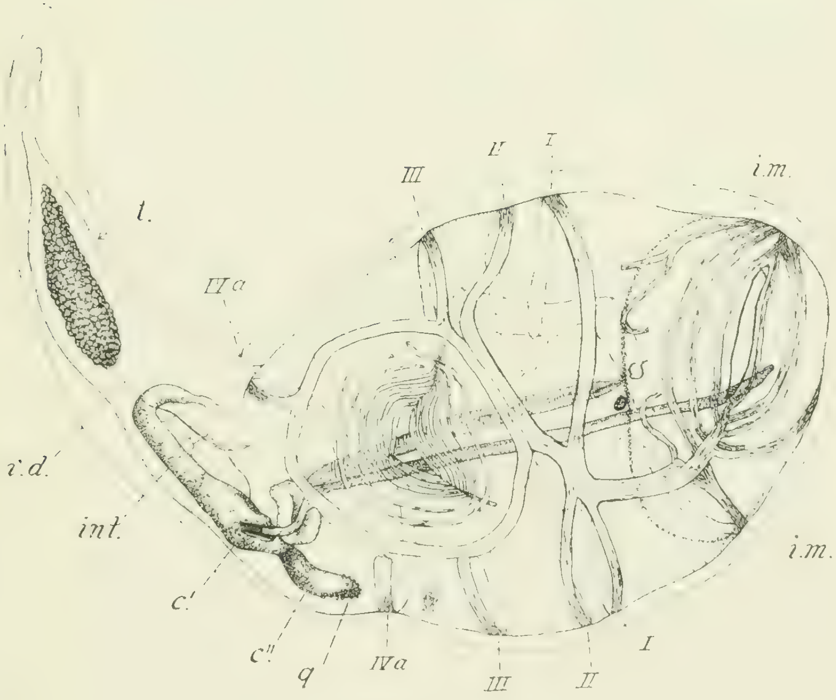

V
I
III
i.m.
t.
IVa
i.d.
int.
i.m.
c'
c''
q
IVa
III
II
I

Fig. 33.

Cyclosalpa virgula. Aggregated Zooid. 31, Dorsal View of Ganglion, Eye, and Neural Glands; 32, Ciliated Funnel; 33, Zooid in Dorsal View, × 4.

For explanation of plate see page 182.

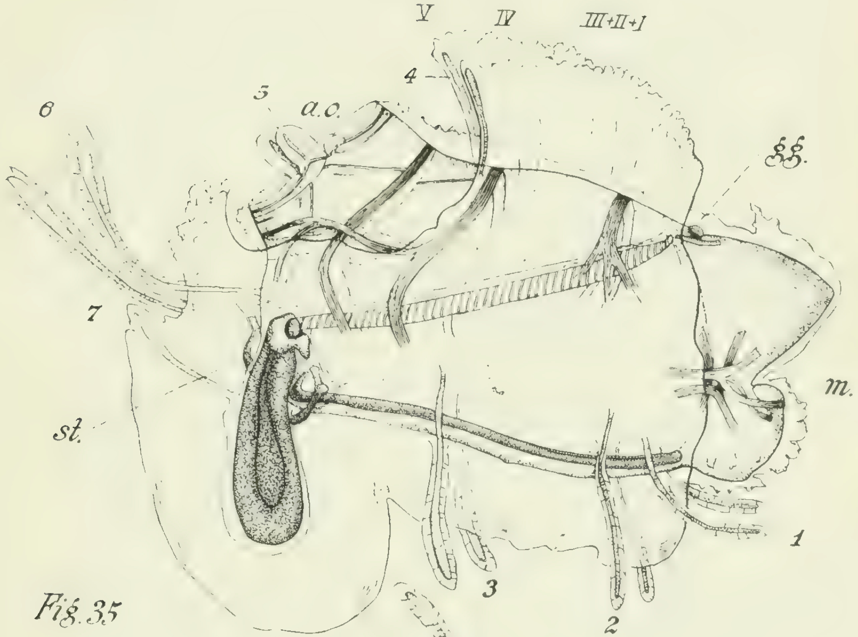

V
IV
III+II+I
4
5
a.o.
6
gg.
7
m.
st.
1
3
2

Fig. 35

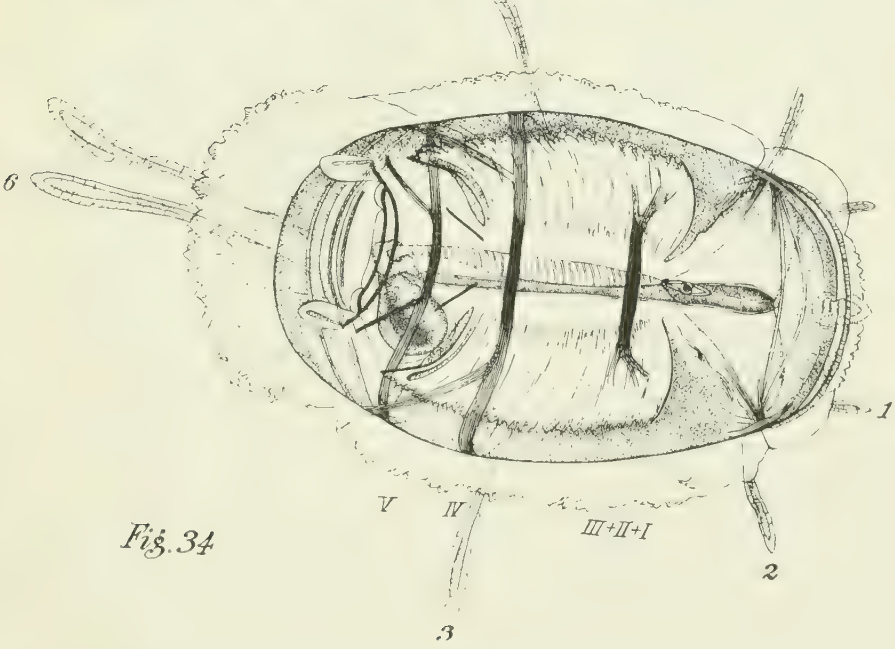

6
1
V
IV
III+II+I
2
3

Fig. 34

TRAUSTEDTIA MULTITENLACULATA, SUBSPECIES BICRISTATA, SOLITARY FORM. 34, DORSAL VIEW, × 11; 35, VIEW FROM RIGHT SIDE, × 11.

FOR EXPLANATION OF PLATE SEE PAGE 182.

APPENDIX.

Since the foregoing paper was written the United States National Museum has obtained specimens of *Apsteinia asymmetrica* by exchange with Prof. Max Weber, of Amsterdam.[1] The author wishes to express his cordial thanks to Prof. J. E. W. Ihle, of Amsterdam, for arranging this exchange.

The adult individuals of both solitary and aggregated forms are so flabby and collapsed as to be difficult to study, but there is among them a beautifully preserved embryo 2½ millimeters long. As this embryo shows the muscles in essentially adult condition, it is used chiefly in the following description of the structure in the solitary individual.

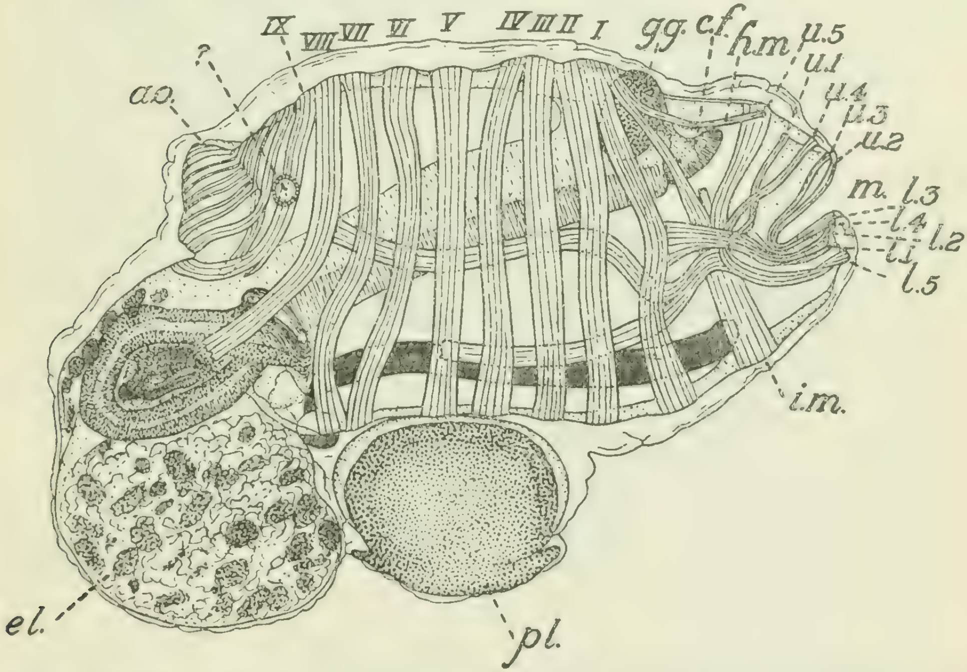


FIG. 140.—APSTEINIA ASYMMETRICA, AN EMBRYO 2½ MM. LONG, VIEWED FROM THE RIGHT SIDE. × 44 DIAMETERS.

APSTEINIA ASYMMETRICA, solitary form.

The body muscles (fig. 140) grade off behind into the cloacal sphincters in such a way that there is no sharp distinction between the two sets. Using the same notation as in *Apsteinia punctata*

NOTE.—The lettering of the figures in this appendix is the same as in the main paper. See the Explanation of Text Figures and Plates on p. 179.

[1] Cat. No. 6733, U. S. N. M. (immature aggregated zoöids from chain). Cat. No. 6734, U. S. N. M. (solitary and aggregated forms). Cat. No. 6735, U. S. N. M. (embryo), 1 specimen.

(fig. 49, p. 72) and the *Cyclosalpas* (pl. 1, fig. 1; pl. 3, fig. 9; pl. 7, fig. 19; pl. 11, fig. 26), we might assign eight or perhaps nine to the body muscle series, preferably nine. In any case the two species closely agree in musculature, body muscle IX (or the basal cloacal muscle, if one prefers so to name it) being the same in the two, showing the same abortive anterior branch below and the same well developed posterior branch passing around the body between the cloacal siphon and the gut evagination.

The intermediate muscle is large and the horizontal muscle well developed. There are five oral sphincters in each lip. The first and second sphincters of the lower lip lie upon the incurved portion of the lip. Posteriorly they unite to form the dorsal oral retractor muscle, which is continuous with them alone. As in *Apsteinia punctata* (figs. 49, p. 72; and 50), the posterior end of the dorsal oral retractor abuts upon the front edge of the first body muscle. Also the ventral oral retractor divides posteriorly into dorsal and ventral branches, the dorsal one of which runs back as far as the eighth body muscle, the ventral branch being shorter. In *A. asymmetrica* it reaches to the middle of the fifth body muscle, being a little longer than in *A. punctata*. The ventral oral retractor muscle divides anteriorly to form muscle 5 of the lower lip and muscle 4

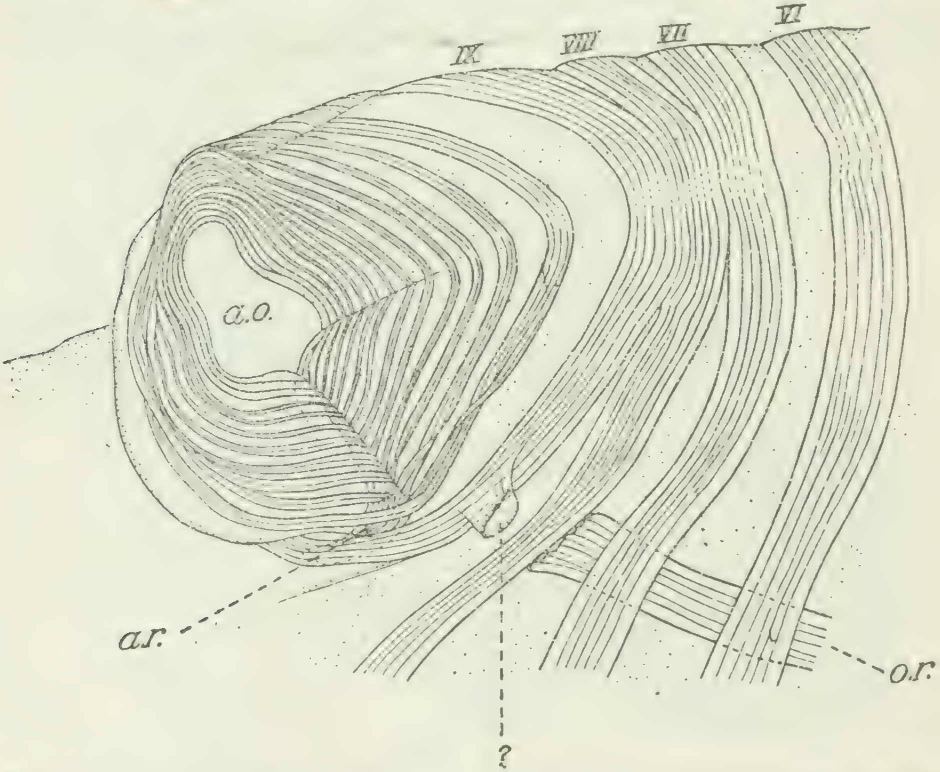


FIG. 141.—APSTEINIA ASYMMETRICA, EMBRYO. A DORSO-LATERAL VIEW OF THE ATRIAL SIPHON AND THE ADJACENT PARTS. × 102 DIAMETERS.

of the upper lip. Muscle 5 of the upper lip is a branch of the intermediate muscle. Muscle 1 of the upper lip lies at its incurved edge. Posteriorly it is in contact with the dorsal retractor muscle and functions with it, though the fibers of the two muscles are not continuous. Muscles 2 and 3 of the upper lip are continuous, respectively, with muscles 3 and 4 of the lower lip and are not connected with either oral retractor muscle. The little blunt protuberance in figure 140, in the angle between the intermediate muscle and the fifth sphincter of the upper lip, is not a muscle, but a blood vessel.

The atrial muscles (figs. 140 and 141) form a graduated series, as in *Apsteinia punctata* (figs. 49 and 52, pp. 72 and 74), and show a similar atrial retractor.

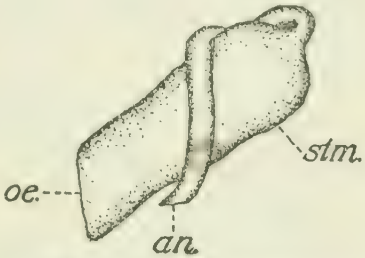


FIG. 142.—APSTEINIA ASYMMETRICA, SOLITARY FORM. VENTRAL VIEW OF THE OESOPHAGUS, STOMACH, AND INTESTINES FROM AN INDIVIDUAL 18 MM. LONG, SHOWING ADULT CHARACTER.

Over body muscle IX, on each side, in the embryo, is a small, very short epithelial tube with collapsed, but not open, end. It is indicated by a question mark on figures 140 and 141. The function of these structures is doubtful, but one suspects they may serve as aids in attaching the embryo to its nurse. These organs are not present in our adult specimens. The much longer postero-lateral languets, shown by Apstein in the embryo of this species which he figures (fig. 58, p. 78), are probably the same structure.

The placenta and eleoblast are in the usual condition. The gut in the embryo forms an open loop around the intestinal gland. In the adult the gut is more compact (fig. 142), really forming a so-called intestinal nucleus, though the elongated character of the stomach makes this "nucleus" less spherical than in the true *Salpae*.

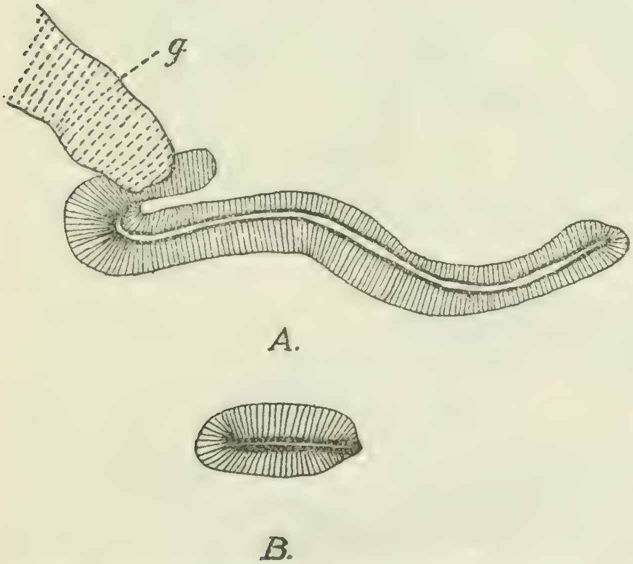


FIG. 143.—APSTENIA ASYMMETRICA. DORSAL VIEWS: *A* OF THE CILIATED FUNNEL AND ANTERIOR END OF THE GILL OF AN ADULT SOLITARY INDIVIDUAL × 50 DIAMETERS; *B* OF THE CILIATED FUNNEL OF AN ADULT AGGREGATED ZOÖID.

The eye is not fully formed in the embryo we have. In the adult solitary individuals (fig. 144) it has the usual horseshoe form, except that the horns of the horseshoe are parallel and straight instead of curved.

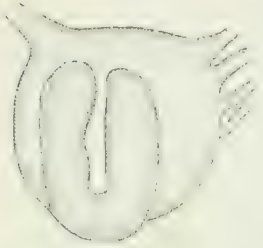


FIG. 144.—APSTEINIA ASYMMETRICA, SOLITARY FORM. DORSAL VIEW OF THE GANGLION AND EYE OF AN ADULT. × 117 DIAMETERS.

In the adult solitary individual the eleoblast has disappeared with the placenta, and the intestinal "nucleus" drops down, allowing the atrical siphon to extend more backward instead of upward, the form of the body resembling that of *Apsteinia punctata* (fig. 49, p. 72).

APSTEINIA ASYMMETRICA, aggregated form.

The adult aggregated zoöids in our material are so soft and collapsed that one can not determine the normal form of the body. Therefore no drawings of the adult are here included. There are, however, some excellently preserved young zoöids still attached to the stolon. All of the

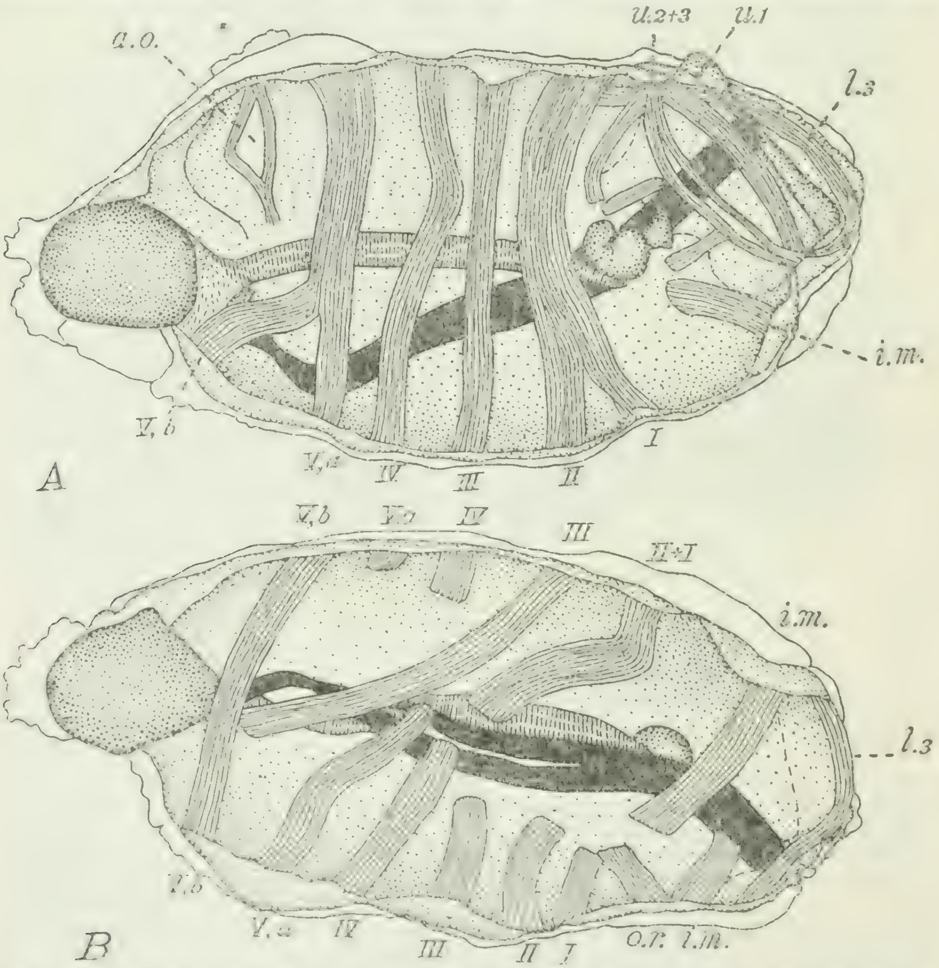


FIG. 145.—APSTEINIA ASYMMETRICA, AGGREGATED FORM. IMMATURE ZOÖID STILL ATTACHED TO THE STOLON: *A:* DORSAL VIEW; *B:* VENTRAL VIEW. × 63½ DIAMETERS.

organs seem to be fully formed, except that the atrial aperture has not yet opened. The general structure, including the musculature, will be described from these small zoöids.

In dorsal view (fig. 145*A*) one sees that the mouth and atrial siphon are decidedly asymmetrical, right or left according to the position of the zoöid in the chain. The muscles in dorsal view show some asymmetry, and in ventral view their asymmetry is seen to be very great (fig. 145*B*).

Musculature.—There are five body muscles. I and II are fused over most of the dorsal surface. II, III, and IV are in contact, or nearly so, in the region which corresponds apparently to the mid-dorsal line. Muscles I–V,*a* are interrupted ventrally, their ventral ends being very asymmetrically placed, as shown in figure 145*B*. Body muscle V is branched, as is usual with the last body muscle. Its anterior branches, V,*a*, are interrupted and very asymmetrical ventrally. The posterior branches, V,*b*, are continuous across the ventral surface in front of the intestinal nucleus.

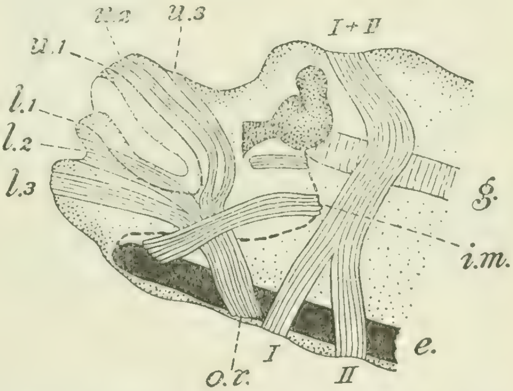


FIG. 146.—APSTEINIA ASYMMETRICA, AGGREGATED FORM. ORAL MUSCULATURE OF AN IMMATURE ZOÖID, VIEWED FROM THE LEFT SIDE. × 63½ DIAMETERS.

The oral muscles are best seen in side view (fig. 146). The intermediate muscles are not alike on the two sides. On the left side of a larval zoöid this muscle arises below near the endostyle, running up and back, passing outside the oral retractor, and reaches the anterior edge of body muscle I. On the right side it rises below well to the left of the endostyle (fig. 145*A*), and curves up to about the level of the ganglion but does not reach body muscle I. The dorsal horizontal muscle is present on each side, stretching from the third sphincter of the upper lip to near the upper end of the intermediate muscle. There is a well-developed oral retractor muscle and three sphincters in each lip, the two sides being nearly alike. The first sphincter in each lip is submarginal and delicate. The second is wider, and the third is still broader. In dorsal view, sphincters 2 and 3 of the upper lip seem almost to form one band, but this is due to a foreshortened view of these muscles as they lie on the inclined dorsal surface of the oral siphon. In side view the true relations appear.

The atrial muscles in the young zoöids are as shown in figure 147, the condition evidently being one of immaturity. Over the future atrial pore lies an enlarged blood sinus, and further atrial sphincters will doubtless form in this region. There is a well-defined atrial retractor muscle on each side. There are two circular basal sphincters independent of the retractors, and three delicate distal branches of the retractors functioning as sphincter muscles. The retractor muscles are continued into the tip of the atrial siphon into the region overlaid by the blood sinus, where apparently further sphincter fibers are to be formed.

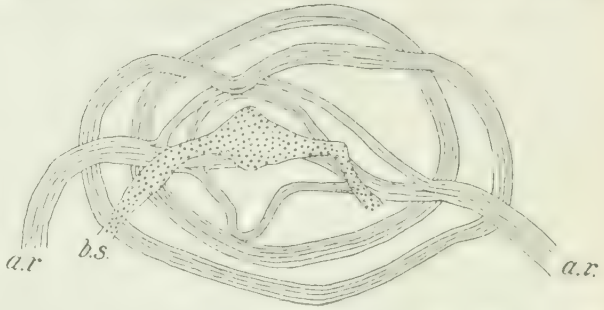
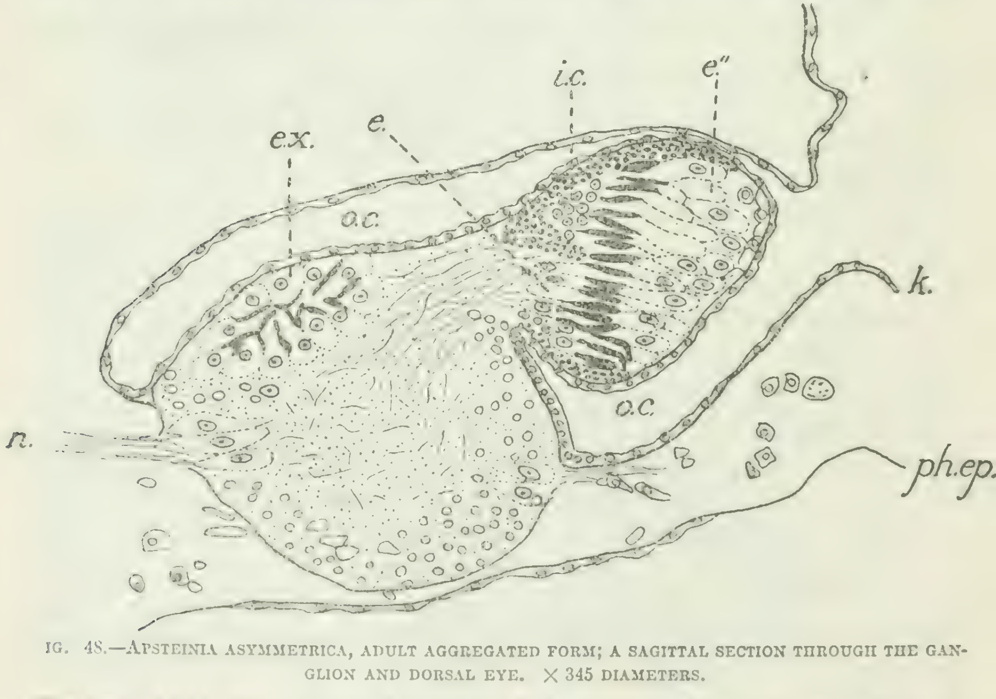


FIG. 147.—APSTEINIA ASYMMETRICA, AGGREGATED FORM. DORSAL VIEW OF THE ATRIAL MUSCULATURE OF AN IMMATURE ZOÖID. × 184 DIAMETERS.

The gut is a compact "nucleus." The endostyle is asymmetrical, its anterior end in a laeval zoöid bending to the left, its posterior end bending to the right.

The eyes almost exactly resemble those of *Apsteinia punctata*, as is shown by a comparison of figure 148 with figure 57 (p. 78).



IG. 48.—APSTEINIA ASYMMETRICA, ADULT AGGREGATED FORM; A SAGITTAL SECTION THROUGH THE GANGLION AND DORSAL EYE. × 345 DIAMETERS.

Observe that the zone of origin of the nerves from the ganglion (*n* in fig. 148 and *zz* in fig. 57, p. 78) is horizontal in *A. asymmetrica* and inclined 45° in *A. punctata*, showing that in the latter species the ganglion has rotated forward 40° more than it has in *A. asymmetrica*.

The neural glands (fig. 149) are about as in *Apsteinia punctata*, but the ducts and their apertures are very wide. On the posterior face of the ganglion on each side, there is a large outgrowth from the ganglion (fig. 150) containing chiefly large cells like those in the ganglion in the zone of origin of the nerves. Nerve fibers from the ganglion run into these outgrowths, and from the outgrowths arise some of the nerves. These postero-lateral outgrowths recall the lateral outgrowths from the ganglion of *Ritteria hexagona* (fig. 47, p. 71), but they do not contain rod cells as in the latter species. They suggest comparison also with the large-celled outgrowths from the ganglion of *Cyclosalpa* (*b′* in fig. 7, *B*, p. 18), and like the latter are not in contact with the neural glands.

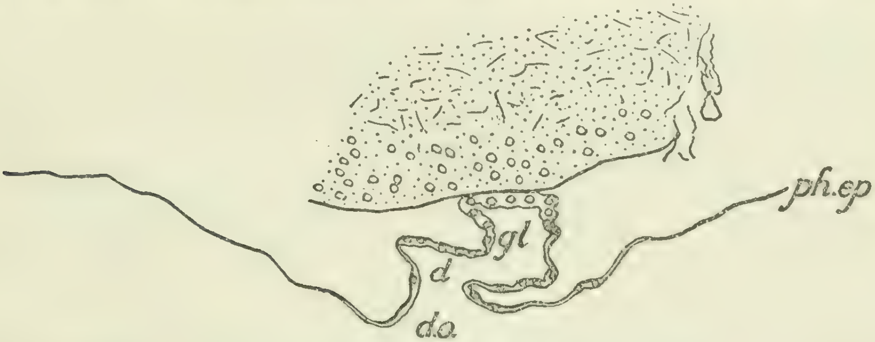


FIG. 149.—APSTEINIA ASYMMETRICA, ADULT AGGREGATED FORM. AN OBLIQUE VERTICAL SECTION THROUGH ONE OF THE TWO NEURAL GLANDS AND ITS DUCT. × 345 DIAMETERS.

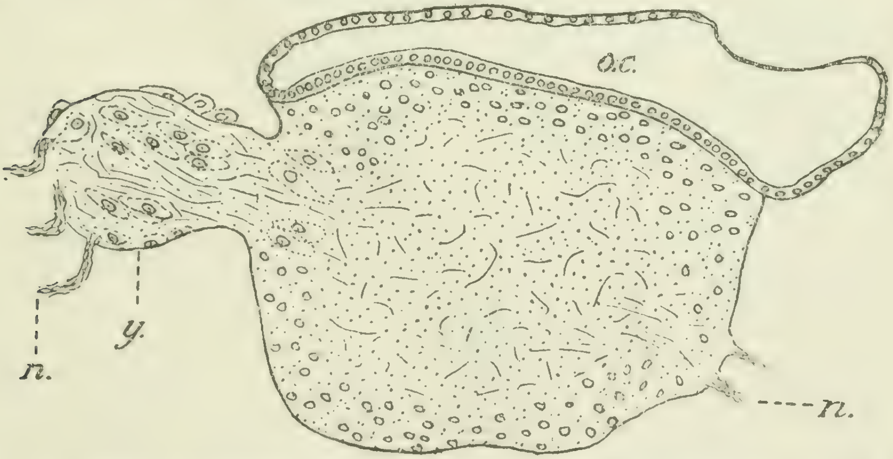


FIG. 150.—APSTEINIA ASYMMETRICA, AGGREGATED ZOÖID, AN OBLIQUE VERTICAL SECTION THROUGH THE GANGLION. × 345 DIAMETERS. AT *y* IS SHOWN ONE OF THE TWO LATERAL OUTGROWTHS FROM THE POSTERIOR FACE OF THE GANGLION.

It is evident that *Apsteinia asymmetrica* and *A. punctata* are very closely related. The somewhat more elongated form of the intestinal "nucleus" in the former suggests that it is probably the more primitive. The greater asymmetry of its aggregated zooid points in the same direction. (See the chart of relationships on page 158.)

The manuscript of this appendix was completed in October, 1917.

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PYROSOMA.—A TAXONOMIC STUDY, BASED UPON THE COLLECTIONS OF THE UNITED STATES BUREAU OF FISHERIES AND THE UNITED STATES NATIONAL MUSEUM.

By Maynard M. Metcalf and Hoyt S. Hopkins,
Of Oberlin, Ohio.

INTRODUCTION.

The family Pyrosomidae is generally regarded as containing but one genus *Pyrosoma*. There are, however, two very distinct groups in the family, the *Pyrosomata ambulata* and the *Pyrosomata fixata*, which might as properly be regarded as two separate genera. In this paper we are treating them as subgenera, although it would be equally well to give each group its own generic name. The members of the family all have the form of free swimming, tubular colonies, and they all emit a strong phosphorescent light. They are said to be the most brilliantly luminous of all marine organisms.

Pyrosoma was first described by Peron (1804), and was later more thoroughly studied by Lesueur (1815). The earlier specimens known came from the Atlantic Ocean and Mediterranean Sea, but many have since been collected from all seas, with the exception of the Arctic Ocean. About sixteen species and varieties are now known, including the new forms described in this paper, whereas previous to the year 1895 only three had been described. In that year appeared Seeliger's memoir, "Die Pyrosomen der Plankton Expedition," and this was followed by important memoirs by Neumann and others upon collections made by different oceanographic expeditions. The anatomy, embryology, and budding have been well studied, but little is known of the behavior of the living animals or of their physiology.

Our studies are based upon the remarkably rich collections of the United States Fisheries Steamer *Albatross* in Philippine waters during the years 1908 and 1909 and upon the extensive collections in the United States National Museum, made almost wholly by vessels of the United States Bureau of Fisheries, chiefly the steamer *Albatross*, which since 1883 has been almost continuously engaged in oceanographic studies. The Plankton, the German Deep-Sea and the German South-Polar Expeditions all made important collections, but all of these combined do not equal in number of types the collections of the *Albatross* Philippine Expedition. We have had for study two hundred and thirteen colonies, comprising thirteen species and varieties, including all but four of the forms of *Pyrosoma* hitherto described, and our collections contain six undescribed forms. The abundance of material is but little less important than the number of species and subspecies represented, for the genus is one in which many of the forms intergrade in a way that can only be made to appear from study of extensive collections. We wish to express to the United States Commissioner of Fish and Fisheries and to the authorities of the United States National Museum our hearty thanks for the privilege of working upon these great collections, among the most extensive and probably the most varied ever gathered.

At the same time that work upon these collections has been going forward, there have been under way studies by the senior author upon the United States Bureau of Fisheries and United States National Museum collections of Salpidae, gathered in general from the same waters as the collections of *Pyrosoma*. Among the Salpidae, species are sharply distinct. In the genus *Pyrosoma*, on the other hand, there is such intergradation that entirely confident demarcation of species and subspecies is not possible. Intercrossing between species is not indicated among the Salpidae. Among the *Pyrosomata* it is altogether probable, cross fertilization seeming to be universal, and different forms being known to be present together in the same waters. Under these conditions it is probable that some of the forms of *Pyrosoma* found are but transient forms, the genus being in flux, interbreeding causing new combinations of characters to appear from generation to generation.

How shall such a genus be treated from the taxonomic point of view? Upon a strictly scientific definition of species every mutation, however slight the divergence, if it be a true mutation, establishes a new species with a new species mean around which is clustered a whole group of conditions due to fluctuating variation. Whether mutation is now occurring often in *Pyrosoma* we do not know. It must have been frequent in the past, establishing a remarkable series of divergent conditions in regard to many of the characters of the organism, for we find such diversity today in these characters.

Does each combination of conditions of the several characters, which we find today, represent properly a species, or are such combinations, due to the mere shuffling of characters, not to be so regarded? The first appearance of a new character, or of a new condition of an old character, arising through mutation, must be said, strictly considered, to produce a new species. Any attempt at demarcation of species on any other basis, within a mutating and interbreeding group of organisms, introduces too much of the personal judgment of the student to be truly scientific.

If into a group like *Pyrosoma* there should be introduced some influence preventing interbreeding, of course each combination of characters now present would be persistent and would represent a true species, however similar some of these species might be to one another.

If some of these forms were to be exterminated, leaving the gaps between species more evident, the specific value of the remaining complexes of qualities would be more clearly seen, but no more real.

But the treatment of each of these complexes of characters as a true species to be described and illustrated compels us to almost endless labor and produces results intelligible only to special students who have the minutest details of structure clearly in mind. It is not a practical solution of the taxonomic problem. One must adopt a more conventional conception of species than this.

In the genus *Pyrosoma*. so far as now known, there is one major line of cleavage, apparently not obscured by intercrossing. This may be indicated by recognizing two subgenera, *Pyrosomata fixata* and *Pyrosomata ambulata*, and we find that these prove to be sharply distinct. Within each subgenus so recognized, there are divergent groups of forms, and between some of these groups intergradation is not observed or is far from complete. These groups may conveniently be classed as species. Minor divergencies within these groups, where intergradation is imperfect, may be given subspecific value. There remain still, especially in the group we name *atlanticum*, a number of forms which diverge considerably at the extremes, but completely intergrade through intermediate forms. What shall we do with these? We cannot describe each condition observed. This would mean a separate description for almost each colony. We compromise by describing as a "*forma*" *dipleurosoma*, one of the most interesting conditions, and grouping the rest under the convenient but not scientifically classificatory term "*intermedium*."

What is the meaning of the taxonomic conditions described for *Pyrosoma*? What has been the history of the genus? Were the lines of cleavage into "subgenera," "species" and "subspecies," which we find to-day, established long ago, to become partially obscured by a more recent period of mutation accompanied by interbreeding, or are the subdivisions of the genus becoming established in the midst of present conditions? I do not see that the data we possess can be so analyzed as to answer these questions for us. We do not even know whether mutation is continuing at present. Until we can answer this most fundamental question there seems little chance of even valuable conjecture as to the further questions that suggest themselves.

There are, of course, many parallels to the condition of flux seen in *Pyrosoma*, especially in the *atlanticum* group. Perhaps as striking an example as any is seen in *Neritina virginea* (Metcalf, 1904), whose color and color pattern show the greatest divergence in different individuals and the most complete intergradation between any two forms one may select. Similarly the silver spot butterflies (*Argynnis*), which have been analyzed into many species, show complete intergradation between the divergent forms. The conditions here, as in *Pyrosoma*, suggest constant interbreeding between numerous forms originally established by divergent mutation. In all groups of this sort, which show such perfect intergrading, species as used in taxonomy, must be purely conventional. Only in groups where physiological, or other, isolation prevails can species distinctions of any considerable magnitude and of scientific value be made. In these groups taxonomic systems can be real, can express clearly observed natural conditions. In groups like *Pyrosoma atlanticum* the lines of demarcation into subdivisions must in part be artificial.

We have assumed in the foregoing that interbreeding between divergent forms is prevalent among the *Pyrosomas*. The conditions in the genus seem different from those in a genus which is merely given to great mutation without interbreeding. Such a genus is *Opalina* among the Protozoa *Ciliata*, a genus the senior author has been studying at the same time that these studies of *Pyrosoma* have been going forward. The species of *Opalina* are numerous and there are species which intergrade between more divergent species, but the distinctions here seem to be truly specific. For example in several cases, in species so similar that one is at first doubtful if they be distinct, the number of chromosomes in the nuclei of the two forms is found to be different. This seems a conclusive distinction. In other cases the form of the mitotic figure is different in species otherwise so similar as to be distinguished only with difficulty. The isolation of the several species of *Opalina* within their often distinctive hosts, for all are parasitic, makes the possibility of interbreeding seem slight. Among the *Opalinae* we have apparently numerous species[1] truly independent, which have arisen through a strong tendency to divergent mutation, and we do not seem to have in this group any reshuffling of unit characters through interbreeding.

Salpa, *Pyrosoma*, and *Opalina*, therefore, present taxonomic conditions very interesting to compare. *Salpa* shows very distinct species which do not intergrade and are not interbreeding. *Opalina* presents species which in some cases very perfectly intergrade but apparently do not interbreed, their intergrading being due to the completeness of the response to the influences tending to produce mutants. In *Pyrosoma* there has been abundant mutation in many of the characters, and the conditions strongly suggest that at least some of the different forms are freely interbreeding, causing a permutation of the several qualities into almost all possible combinations. It would be interesting to do for *Pyrosoma* what has been done for *Opalina* and to test for some of the more similar forms the question of their specific distinctness by determining the chromosome number. Our material, however, is not suitable for such study.

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[1] These considerations are based upon the study of a number of as yet undescribed American forms, as well as upon the well-known species.

This introductory discussion of the meaning of our taxonomic distinctions has seemed necessary before entering upon the description of the different forms of *Pyrosoma*. We trust it has given the reader an understanding of the difficulties that have confronted us and will make him more kindly disposed toward our conclusions as expressed in our classification. The results are unavoidably somewhat vague and uncertain. The facts of structure of course are clear, but the digestion of these phenomena and their expression in a definitive classification is in considerable measure a matter of judgment.

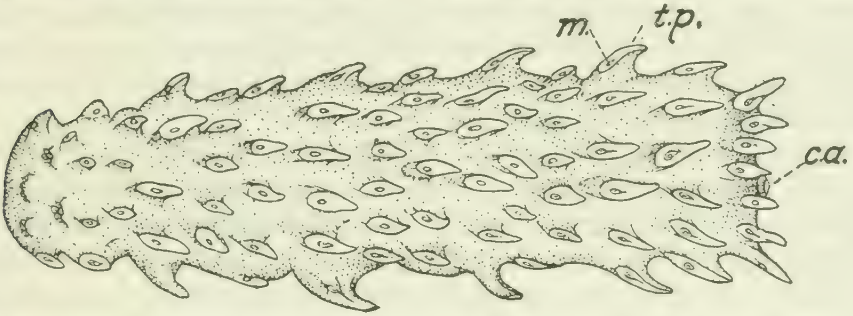

Fig. 1.—A colony of Pyrosoma atlanticum atlanticum; twice natural size. After Ritter (1905). For significance of reference letters see Explanation of Plates, p. 268.

GENERAL DESCRIPTION.

Pyrosoma has the form of a compact colony composed of numerous individuals or ascidiozoöids imbedded in a gelatinous tube which is generally rather long, of somewhat uniform diameter, closed at one end and open at the other (fig. 1). The zoöids are placed with their oral apertures to the outer surface of this tube, the atriopores opening into the common axial colonial chamber. Thus the respiratory current passes from the outside, through the zoöids, into the colonial tube, and thence to the exterior by way of the colonial aperture. A longitudinal section through the entire colony (fig. 2) reveals the form to best advantage. The cormus is nearly cylin-

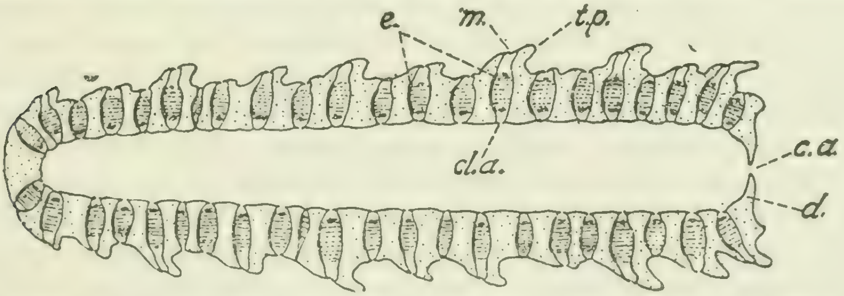

Fig. 2.—A diagrammatic longitudinal section of a Pyrosoma colony; twice natural size.

drical, usually tapering somewhat toward the closed end. The zoöids are found to be arranged radially around the central axis. At the open end of the colony the aperture is bounded by a diaphragm, a shelflike continuation of the test, serving to narrow the aperture. This diaphragm contains numerous spindle cells, which for the most part are arranged in circles parallel with the free edge of the diaphragm, and have even been observed by Seeliger to form definite circular bands. Whether these are contractile or not is unknown. Seeliger thinks them merely elastic, but the similarity between these cells and those at the frayed-out ends of some of the muscles of the zoöids suggests strongly that they may be muscular, and effective in contracting the colonial aperture.

The thickness of the test walls is nearly uniform for each colony, and this corresponds roughly to the normal length of the zoöids; it ranges from about 0.2 cm. to 2.0 cm. This maximum thickness is reached only in large colonies of *P. spinosum*. Often the test is colorless and transparent, but in many preserved specimens it is slightly colored—yellowish, blue-green, grayish or flesh colored, the colony as a whole appearing darker because of the opacity of the zoöids.

The test may be soft and gelatinous or rigid and cartilaginous, in some forms even leathery. Usually it is fairly firm and gives to the colony some definite form, which may be characteristic of the species. It appears that in the subgenus *Pyrosomata fixata* the test is always flabby and gelatinous; even alcoholic specimens, which ordinarily are quite hard, in this subgenus are surprisingly limp.

The arrangement of the individual zoöids can be seen from a superficial examination of the entire colony. The zoöids, with only occasional exceptions, are disposed with their dorsal sides directed toward the open end of the colony. In some of the larger forms (*P. atlanticum giganteum*, *P. ovatum*) it is not uncommon to find some zoöids turned around, so that their ventral sides are directed toward the colonial aperture. Keferstein and Ehlers (1861) described this position of the zoöids as a diagnostic character of the species "*P. elegans*," but this seems unwarranted, since it is found, to a greater or less degree, in a number of species, and seems to be due merely to overcrowding of the zoöids. Seeliger thinks Keferstein and Ehlers may have been working on broken specimens, mistaking a broken end for the open end of a colony; or that perhaps they examined *P. aherniosum* colonies, which are sometimes larger at the closed than at the open end, and that they overlooked the position of the aperture. An orderly arrangement of the zoöids obtains in some species. In the young colonies of almost all types there is some degree of regularity (fig. 53, pl. 36). This may persist throughout life in the smaller, verticillate forms, but generally in a modified way (fig. 54, pl. 36); or it may become completely obliterated in others (*P. atlan-*

ticum and subspecies, pl. 34). *P. spinosum* acquires a degree of regularity in the arrangement of its zoöids, but only after it becomes large and mature. It then contains longitudinal rows of zoöids, those of one row alternating with those of the next. In *P. verticillatum* and a few related species the regularity arises with the earliest budding of the zoöids, these coming to lie in both longitudinal and transverse rows (figs. 43 and 44, pl. 33). The longitudinal rows soon become obscured, but the transverse rows (verticils) persist.

The older distinction for dividing the genus into two groups (Savigny, 1816) according to the arrangement of the zoöids in the colony, whether regular or irregular, appears not to have been well grounded. The form designated as "*P. elegans*," whose zoöids were regularly arranged, was probably a young specimen of some form of the species we treat as *P. atlanticum*, since some of these forms are known to pass through a stage in which the zoöids are arranged with a considerable degree of regularity. This original distinction should not be confused, however, with that which now holds good in separating the so-called verticillate forms from the others of the genus. These have all been discovered very recently (1909 and subsequently).

The test. The outer surface is never quite smooth and even. The embryo, at least in several species, when first released from the parent colony, developes spine-like outgrowths of the test, which apparently aid in suspending the young animal in the water. These are purely embryonic structures, however, which always disappear after the new colony has commenced active growth through budding. In many species of *Pyrosoma* true test processes are present on the adult colony. These processes are of two distinct types. Those characteristic of the group *Pyrosomata fixata* are small, quadrangular spines, located on the test surface, just ventral to the oral apertures of the zoöids (fig. 6, pl. 18 and fig. 8, pl. 19). Originally they point slightly in the direction of the open end of the colony, thus giving one the impression that they slightly overarch the oral apertures of the zoöids. The test processes of the other type, which are found in some species of *Pyrosomata ambulata*, always occur in connection with zoöids; that is, each test process surmounts a zoöid, whose oral siphon traverses the length of the test process to open by the mouth upon its truncated ventral surface, or at its distal end (fig. 45, pl. 34, and fig. 30, pl. 26). This relation often gives rise to long buccal siphons surrounded by the tubular outgrowths of the test (as in *P. ovatum*, *P. aherniosum*, and others. See fig. 26, pl. 25). There are no other definitive spines or processes found in any members of this sub-genus, which originate independently of the zoöids. Irregularities and denticulations of the test are found, but they are, for the most part, unimportant. In some cases this roughened or denticulate condition gives to the colony a peculiar opacity. It is occasionally of some taxonomic value, as will be noted later.

Certain other structures should be described here, on account of their relation to the colony as a unit, namely: the vessels of the tunic and the fibers connecting the cloacal muscles of adjacent zoöids. Discussing the latter first, it is probably by means of these fibers that contractile movements among the individuals composing the colony are coordinated, and it may be that the simultaneous action of the cloacal muscles (and the fibers?) is effective to cause contraction of the colonial tube. In any case their action, whether contracting only the individual cloacal chambers, or contracting the whole colonial tube, must bring about locomotion by the expulsion of water from the colony through the aperture at its open end. The longitudinal fibers of the tunic vessels may share in this effect. In the performance of this function there must be some nervous coordination, some means by which the cloacal muscles in all the zoöids are stimulated to contract simultaneously. Since these test fibers are the only connections between the zoöids, they must be the carriers of nervous impulses from one individual to another.

The tunic vessels, above mentioned, appear in the earliest buds of the colony, as ectodermal outgrowths from their dorsal walls. Two are found in connection with each of the four primary ascidio zoöids probably of all the species, and with the subsequently formed zoöids of the *Pyrosomata fixata*. In the other subgenus, however, the secondarily developed buds send out but one vessel each. The tunic vessels are cylindrical tubes consisting of a single epithelial layer lined with longitudinal musle fibers. They all end blindly in the diaphragm of the colony when this is present. They serve the purpose of a colonial circulatory system. In young colonies these vessels are well developed and functionally active, but in adult colonies they often undergo degeneration, especially the enormously elongated vessels which arose in connection with the oldest zoöids.

The test is rich in test-cells. These originate in the mesoderm of the early formed buds and wander out through the ectoderm to their place in the test.

The zoöids (fig. 1, pl. 15) are numerous and almost independent, being held together in a common matrix, the test. They may be examined most readily by cutting out thin sections of the wall of the colony, parallel to its long axis. The outer ectodermal sheath, the epidermis, is attached to the test only at the oral and atrial apertures. As in the other Tunicates, there are two principal body chambers, a pharynx, and an atrium with its two large peribranchial pouches. Between these two chambers, postero-ventrally and near the mid line, lie the viscera, namely, the digestive and reproductive organs and the heart. The muscles of the zoöid (fig. 8, pl. 19) are only weakly developed.

All lie, in general, transverse to the long axis of the body. There are oral and atrial sphincter muscles in all species. A little behind the mouth and encircling the prebranchial chamber, are one to several fine bands or fibers, which we may call the circum-oral muscles (*c. m.*). In the *Pyrosomata fixata* there is a system of branching fibers not found in the other sub-genus, the so-called lateral muscular system. It consists of two transverse strands, a posterior one (*l. m.'*) crossing in front of the ganglion, and an anterior one (*l. m.*) in front of the endostyle, both sets branching somewhat on each side of the body. A pair of transverse, cloacal muscles (*cl. m.*) are found in all Pyrosomas. In the *Pyrosomata ambulata* these lie one on each side of the common cloaca (fig. 37, pl. 30); in the *Pyrosomata fixata* they lie over the middle of the peribranchial sacs (fig. 3, pl. 16). The cloacal muscles of one zoöid are connected with those of adjacent zoöids by means of the test-fibers already referred to.

The oral aperture leads directly into the pharynx. It is circular and is reinforced and held in position by a projecting shelf of the test. The inner epithelium inside the mouth is produced into a number of tentacle-like processes arranged in a ring. In the *Pyrosomata ambulata* only the median, ventral process can be regarded as a true tentacle (fig. 13, pl. 22); the others are really nothing more than thickened folds in the edge of the mouth, although in some species they are quite prominent. In the members of the other subgenus all of these processes are true tentacles (fig. 2, pl. 16). They are each supplied with nerve fibers and are probably sensory, for sensory cells have been discovered in the similarly placed tentacles of other Tunicates (as *Molgula*, Hunter, 1898).[1] The median, large, ventral tentacle is said by Ussow (1876) to contain otoliths in the expanded, vesicle-like portion at its base, but, on the basis of our own and other's observations, this report seems to be mistaken. Ussow's description, if it were accurate, would indicate that the tentacle functions as an organ of direction, through perception of gravity. Joliet (1888) and Salensky (1891) suggest that by distending its basal vesicle with blood the tentacle may be erected so as to close the mouth.

The pharynx shows two portions, the prebranchial chamber (buccal cavity) anterior to the peripharyngeal bands and behind this the branchial sac whose lateral walls form the so-called branchial basket, the respiratory area of the pharynx. The prebranchial chamber is sometimes very short, but in the majority of species it is more or less elongated to form an oral siphon. The water which passes through the mouth into the pharynx makes its way out through the stigmata into the right and left peribranchial sacs, thence into the common cloaca (fig. 3). On the ventral side of the pharynx is the endostyle, extending nearly the whole length of the branchial chamber. The endostyle in *Pyrosoma* does not differ materially from that of other Tunicates. Peripharyngeal bands, continuous with the ciliated ridges bordering the endostyle, pass around the pharynx, immediately in front of the stigmata, uniting behind the ganglion. In the *Pyrosomata ambulata* they come together at a broad angle immediately under the ganglion (fig. 13, pl. 22), but in the *Pyrosomata fixata* they continue backward nearly parallel to each other, one-third to one-half of the distance from the ganglion to the esophageal aperture, where they come together at a very sharp angle (fig. 5, pl. 17). At the point where they unite the dorsal languets commence, the latest formed of these lying in front (fig. 7, pl. 18; fig. 17, pl. 23). The lateral ciliated cells of the endostyle are continued behind onto the postero-ventral wall of the pharynx as an indistinct ciliated band which runs to the opening of the esophagus.

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[1] Compare the less conclusive studies upon *Doliolum* by Keferstein and Ehlers (1861), Grobben (1882), and Uljanin (1884), and Neumann's discussion of the conditions in *Pyrosoma* (1909–13, p. 57).

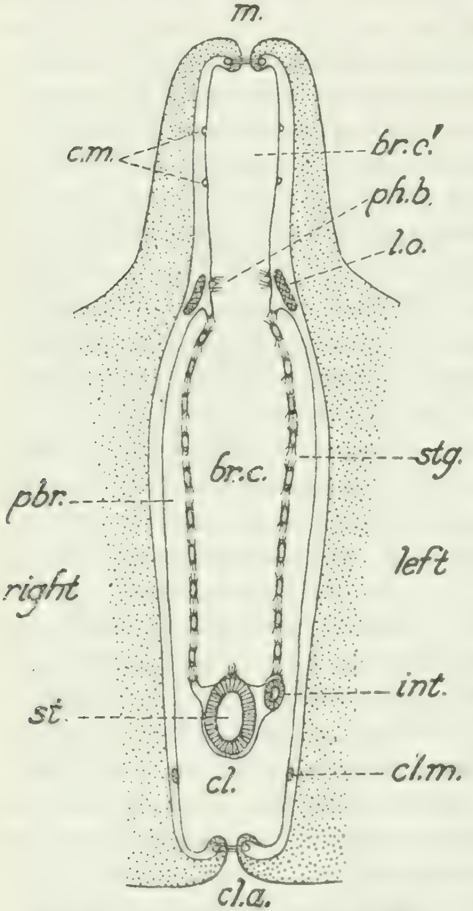

Fig. 3.—A diagrammatic frontal section through a zoöid, of the elongated type, of Pyrosoma atlanticum. The actual number of stigmata is much greater than shown. After Seeliger (1895).

In each of the branchial lamellae are a large number of stigmata which lie in rows. These originate from simple, elongated, transverse gill slits such as are seen in *Doliolum*. In *Pyrosoma* they are divided very early by the growth, across the inner surface of each branchial lamella, of longitudinal folds containing lymphatic liquid, but apparently no corpuscles (Burghause, 1914). Thus the primitive elongated slits are changed into a great number of secondary stigmata which are oblong in shape. The stigmatal rows thus formed do not always lie in a direction transverse (dorso-ventral) to the zooid, but in the *Pyrosomata fixata* they run obliquely from the postero-dorsal to the antero-ventral part of the pharynx (fig. 8, pl. 19). Each stigma is abundantly ciliated, as in other *Tunicata*. Ordinarily the branchial lamellae are oval, elongated in the axis of the zooid; in a few species they are higher (dorso-ventrally) than long (as *P. agassizi*, fig. 3, pl. 16; *P. verticillatum*, fig. 12, pl. 21).

In *Pyrosoma* the organs of digestion resemble very closely those in other Tunicates. They are located centrally in that portion of the body wall which forms a partition between the pharynx and the cloaca. The long axis of this rather open "nucleus" is perpendicular to the antero-posterior axis of the zooid in most cases; in *P. spinosum*, however, it is distinctly oblique (fig. 8, pl. 19). The esophagus is a short, funnel-shaped tube in all species. It opens from the pharynx at its posterior end near the dorsal side, then curves downward, entering the stomach posteriorly (fig. 25, pl. 24; fig. 4, pl. 17). This latter organ is cylindrical, ovoid or triangular. It is sharply demarcated from the esophagus, but is not so distinct from the intestine. Between the stomach and the true intestine is a short, constricted portion, which may be called a pylorus (figs. 17 and 18, pl. 23). The intestinal tube runs ventrally, then curves forward and upward, and opens at the left side of the stomach into the cloacal chamber. The intestinal curve is a sharp loop in some species (fig. 17, pl. 23), while in others it is more evenly curved, or almost circular (fig. 34, pl. 28). In the *Pyrosomata fixata* the intestine curves sharply upward immediately after leaving the stomach (fig. 7, pl. 18; fig. 8, pl. 19). There is a digestive, or pyloric, gland as in other Tunicates. It lies over the distal limb of the intestinal loop as a branching system of tubules. These converge to form the common duct which enters the stomach on the left side near its ventral end (fig. 27, pl. 25).

The peribranchial chambers, one on each side of the pharynx, correspond pretty closely in contour with the branchial lamellae (fig. 3, p. 204.) They are flattened diverticula of the common atrium, extending forward just far enough to receive the exhalent water coming through the stigmata from the pharynx. The lateral walls between pharynx and atrium are very thin, consisting of endoderm, ectoderm, and but little mesoderm, abundant blood lacunae, however, being present. There are delicate trabeculae connecting the inner wall of the peribranchial chamber with the outer one.

The common cloaca, that is, that portion of the atrial chamber lying posterior to the pharynx, is of variable size, forming in most species a considerable cavity (pls. 30 and 31), but in some species it is but a shallow bay opening by a very wide cloacal aperture into the central, colonial chamber (fig. 3, pl. 16). Into the cloaca the sexual elements, the faeces, and the respiratory water are discharged; and it undoubtedly serves, in part at least, to conduct away the products of excretion, though there are no well defined renal organs in *Pyrosoma*. In this cavity, also, the embryo, in some species, continues its development for a period after becoming detached from the ovary. On account of its great diversity in size and structure, no condition of the cloacal aperture can be described as typical. In the *Pyrosomata fixata* it is broad and of variable form (plate-figs. 3, 4, and 8); on its dorsal edge is a flattened, pointed tentacle, which will be referred to as the cloacal tentacle. In the other subgenus the aperture is usually a circular pore (pl. 29).

The small, ovoid ganglion is located dorsally, near the anterior end of the branchial basket. A pigmented layer in its ventral portion probably enables some of the adjacent ganglion cells to perceive not only the presence of light, but also its direction. From the sides of the ganglion the nerves arise, eight pairs in all (fig. 5, pl. 17; fig. 13, pl. 22). Their distribution is characteristically different in the two sub-genera. (See pp. 214 and 225.) Beneath the ganglion, closely applied to its ventral and posterior surfaces, is the subneural gland, and running forward between it and the ganglion is the duct which connects it with the pharynx (fig. 4). The duct in *Pyrosoma* is short and not prominent. Its aperture, the ciliated pit, is oval or round. It is directly beneath or often a little in front of the ganglion

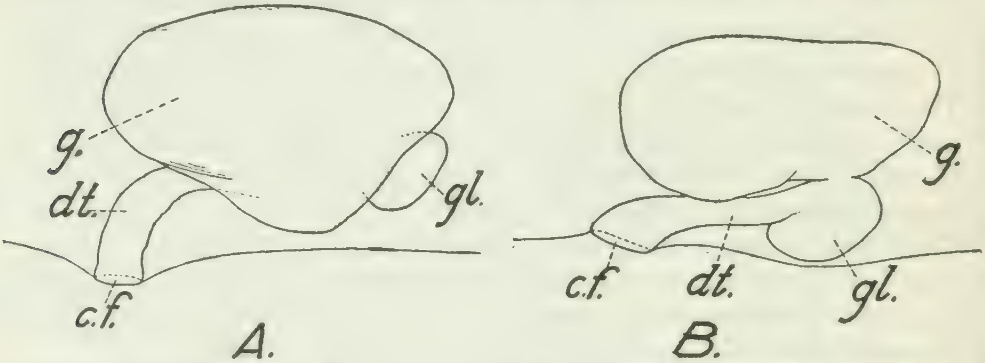

FIG. 4.—OUTLINE DRAWINGS OF THE GANGLION AND NEURAL GLAND: *A*, IN PYROSOMA AGASSIZI; *B*, IN P. ATLANTICUM. × 193 DIAMETERS.

Circulatory system (fig. 1, pl. 15). The heart (*h*) lies at the posterior end and a little to the right of the endostyle. As in other Tunicates, the heart lies within a delicate pericardium, from which it originated by dorsal, median invagination. The fold thus formed is closed along its inner side by the endodermal wall of the pharynx. Each end remains open, communicating with the blood sinuses. Of these sinuses there are three principle ones, and several of secondary importance. A median ventral sinus (*v. s.*), below the endostyle, is continuous in front with a pair of peri-pharyngeal vessels (*ph. s.*), one running along each of the peri-pharyngeal bands, and expanding laterally to contain the cells of the luminous organ (*l. o.*). These two sinuses unite around the ganglion and continue along the dorsal side of the pharynx as a median, dorsal sinus (*d. s.*). The dorsal and ventral sinuses are connected further by means of the transverse vessels of the branchial lamellae, one in each trabecula. This connection is not a direct one, for the branchial vessels open both above and below into longitudinal vessels which lie parallel to the ventral and dorsal sinuses. There are two on each side, one above and one below, following the dorsal and ventral contours of the branchial basket. The two ventral, delimiting, branchial vessels (*v. l. s.*) are connected by numerous ducts with the median ventral sinus, and the two dorsal (*d. l. s.*) are similarly connected with the median dorsal sinus. In the region of the stomach the dorsal sinus breaks up into a ramifying system of branches, which originated in the bud from a large, undivided canal, the visceral sinus (*vc. s*). One branch traverses the stomach and intestine before reaching the heart; others unite posteriorly to form a genital circuit, (*g. s.*), which goes to the gonads, and thence to the heart. The growing stolon is supplied with two vessels, one from each end of the heart. Two small branches of the ventral sinus, one to the oral region (*v. a. s.*) and one to the cloaca, receive blood from two corresponding branches from the dorsal sinus (*d. a. s.* and *d. p. s.*). The tunic vessel (*t. s.*) is supplied with blood from the dorsal sinus, but the blood does not circulate in it. It is through these tunic vessels that some of the mesenchyme elements pass into the cellulose test.

Blood-forming organs. On the dorsal side of the zoöid, some distance in front of the esophageal aperture, there are two elongated masses of mesoderm cells which seem to be leucocytes, lying in an expanded portion of a blood sinus (pl. 15, *b. o.*). The function of these cell masses is uncertain. They were formerly thought to be glandular. Seeliger (1895) found them to contain many actively dividing blood corpuscles, and believes them to be organs for the formation of blood cells.

The luminous organs lie one on each side of the pharynx, just over the peripharyngeal bands (pl. 15, *l. o.*). They are flat, oval masses of mesodermal cells, contained within an enlargement of a blood sinus. They resemble the blood-forming organs in general appearance and structure and in their relation to the blood stream. Their method of producing light is not well understood, though it is probably by the oxidation of a yellowish granular substance within the cells, as seems to be the case in the luminous organs of *Salpa*. Light is also emitted from cells in the region of the intestine and gonads.

Gonads. *Pyrosoma* is hermaphrodite. The organs of reproduction are found in the ventral body wall, below the digestive tract. In the *Pyrosomata fixata* the testis is closely applied to the posteroventral side of the digestive tract (pl. 19, fig. 8, *t.*), and the egg (*ov.*) lies considerably posterior to it. In the other Pyrosomas the testis is at some distance from the digestive tract, the egg developing at the right of the testis (fig. 31, pl. 27). In species with small colonies (those which reach a definitive length of about 4 cm. or less) the majority of zoöids are protogynous. The larger forms, on the contrary, contain a large number of protandrous zoöids, especially during their period of active growth. This condition seems to result from the fact that, in actively budding zoöids, the nutriment demanded by the maturing sex cells is diverted for the formation of buds; hence the development of the egg, which requires a large amount of nutriment, is delayed. The testis is an aggregate of lobes forming an organ of somewhat hemispherical form, either quite compact (pl. 23, figs. 17 and 18), or, in other species, rather open (fig. 22, pl. 24), its lobes forming a sort of rosette. There are a variable number of lobes, from 12 to 20 in the majority of forms, but there may be as many as 77 in *P. spinosum.* These lobes converge on the ventral side (dorsal side in the *Pyrosomata fixata*) from which point the sperm duct arises and leads to the cloaca (fig. 22, pl. 24). The single egg lies in an ovarian vesicle formed by the outer and inner epithelia of the cloacal wall. It contains much yolk and is surrounded by a follicular membrane. In connection with the young egg is a so-called oviduct, a narrow duct dilated next to the egg, which runs forward and opens into the cloaca. It serves as a sperm receptacle. After sperms have entered it, the aperture grows shut and the spermatozoa are retained until the egg is ready for fertilization (fig. 5).

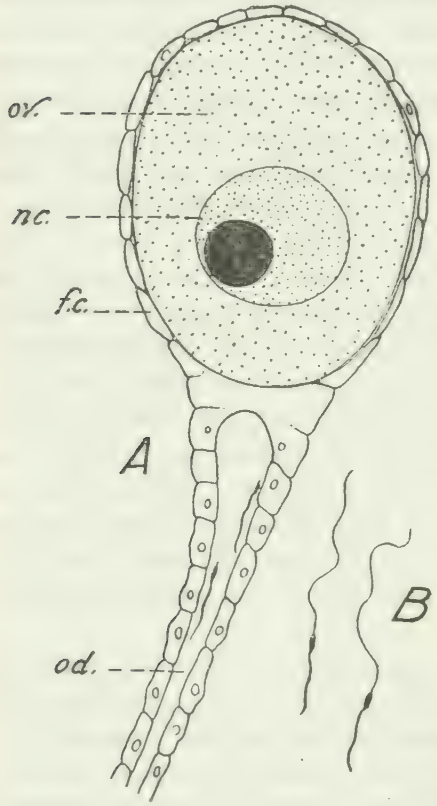

FIG. 5.—PYROSOMA ATLANTICUM PARADOXUM: *A*, OVARY AND OVIDUCT WITH TWO SPERMATOZOA IN THE OVIDUCT, *B*, TWO SPERMATOZOA.

The embryology of *Pyrosoma* is complicated, owing, first, to the large accumulation of yolk in the egg, which distorts the early stages of development; second, to the very early appearance of budding; and, third, to the fact that the cyathozoöid degenerates before reaching fully adult structure. Cleavage is incomplete and discoidal. There are formed by meridional division two, four, and then eight cells, which continue to divide more irregularly, leading to the formation of a flat germinal disk. The embryo develops from a central, thickened portion of this disk (fig. 6). This definitive blastoderm gives rise to two thin layers, one of ectoderm cells, and another of mes-endodermal nature beneath it, both lying above the yolk. A cavity then forms in the mes-endodermal mass of cells, which corresponds probbly to the archenteron. Certain cavities appearing in the axial mesoderm have been referred to as representing the notochord.

The organs of the embryo form very much as they do in other Tunicates (figs. 6 and 7). A neural rudiment (*n. r.*) is defined by the infolding of an ectodermal thickening. There is formed also a ciliated funnel (*c. f.*) communicating with the neural rudiment by a short duct. Two invaginations, one on each side of the neural rudiment, push forward for a considerable distance as peribranchial pouches (*pbr.*). Their apertures grow together later behind the ganglion, forming a common cloacal aperture (*cl.a.*). The mesoderm gives rise anteriorly to a layer of cells inclosing a paired coelomic space, and this to a pair of lateral outgrowths. The right one of these, only, develops a lumen, the pericardial canal, which swells into a pouch distally. This swollen portion becomes separated off as the future pericardium, and the original canal degenerates.

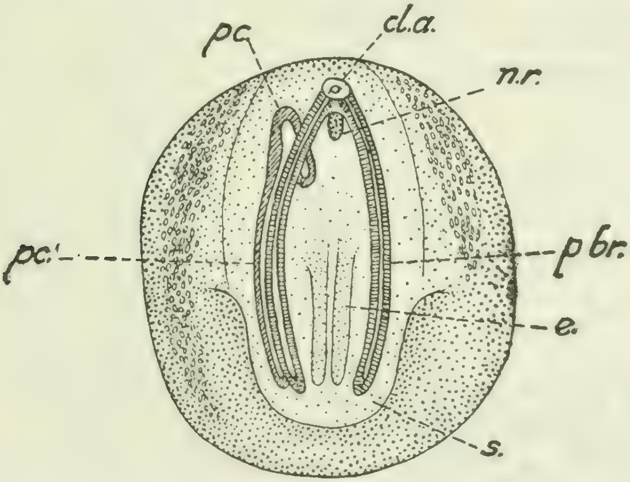

FIG. 6.—AN EMBRYO OF PYROSOMA GIGANTEUM (?). AFTER KOWALEVSKY (1875).

The embryo, at this stage of its development, contains an archenteron, undifferentiated mesoblast cells, a pericardium, a nerve ganglion and ciliated funnel, and peribranchial and cloacal chambers. The energy is now thrown into the formation of a proliferating stolon and the subsequent production of buds. The embryo, from this time on, ceases to become more differentiated, except in a few particulars. A functional circulatory system is evolved, by means of which the yolk nutriment of the embryo is transferred to the growing buds. This first individual, then, which developes from the egg, the so-called cyathozoöid, corresponds to the solitary form of *Doliolum* and of *Salpa* (fig. 7). In *Pyrosoma* the solitary generation is reduced to a transient, embryonic stage. This cyathozoöid gives rise very early to four buds, or primary ascidiozoöids, which in turn bud and form a great number of secondary ascidiozoöids; and thus the colony is established.

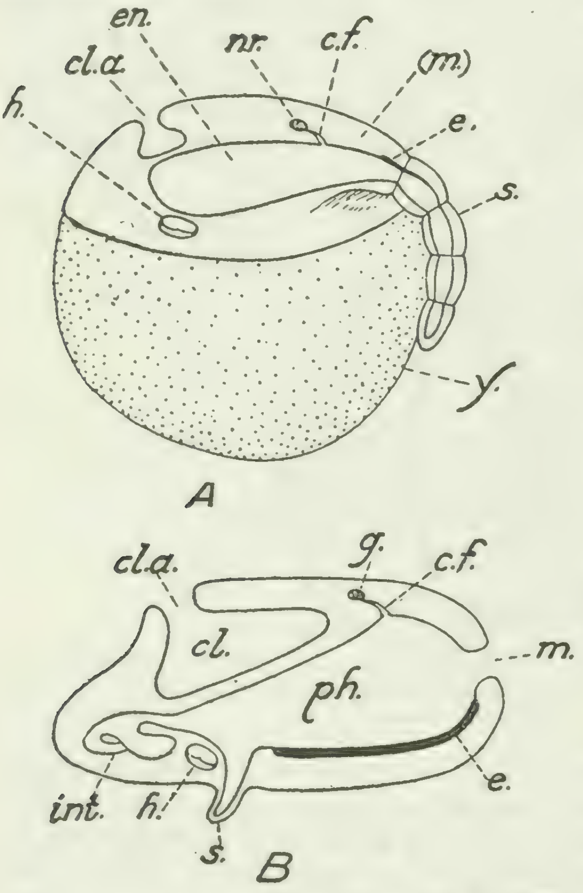

Fig. 7.—Diagrams to show the position of the organs in a Pyrosoma cyathozoöid (*A*) and a Salpa (*B*), solitary form. After Korschelt and Heider (1900).

The stolon of the cyathozoöid develops very early as a prominent, sac-like outgrowth from that end of the embryo which lies opposite to the cloacal aperture (figs. 6 and 7). This outgrowth soon becomes marked off into four short segments, by partial constrictions. Each of these segments is destined to develop into a primary ascidiozoöid. The stolon, originally straight, becomes curved to the left, so that by further growth it comes to encircle equatorially the yolk of the cyathozoöid. The buds all lie with their ventral surfaces distal from the parent.

The earliest organs of the chain of buds originate for the most part as direct continuations of the corresponding organ rudiments in the cyathozoöid. The ectoderm is directly continuous in the two. The enteric canal is a tubular outgrowth running throughout the chain. There is found in the cyathozoöid the rudiment of an endostyle-fold on the outer layer of endoderm, and this also is prolonged into the stolon. In addition to these, are a pair of peribranchial tubes, a transient pericardial tube on the right side of the body, and two strands of mesoblast cells. The nervous system has a new origin in each bud, forming as an invagination of the dorsal ectoderm.

During the growth of its buds the ectoderm of the cyathozoöid secretes a layer of cellulose around itself and its buds, just within the follicle membrane. Later, mesenchyme cells enter this secreted layer, forming the so-called test-cells. Kowalevsky thought that the atrium of the cyathozoöid became the colonial cavity of the colony. According to Salensky, the cyathozoöid degenerates and the colonial aperture has an independent origin. In our colonies we find embryos in which the atrium of the cyathozoöid is completely overgrown by a layer of cellulose. After the four buds become more separated by the constrictions of the stolon each one enlarges through growth and then turns through an angle of 90° so as to take up a position with its dorsal side toward the cloaca of the cyathozoöid. While the aperture of the colony is developing in this region each ascidiozoöid sends out dorsally two ectodermal processes, the test vessels, into the test. At about this stage, or perhaps somewhat earlier, the little tetrazoöid colony is set free from the cloaca of the parent zoöid, passing out of the colony, and commences an independent existence. A mouth and atrial aperture form in connection with each zoöid, the latter communicating with the exterior through the colony chamber. The primary ascidiozoöids are now capable of growing independently and of producing buds for the further development of the colony.

We shall not enter into detail in describing the organogeny of the zoöids. In the four primary ascidiozoöids the processes are somewhat easier to interpret than are those in the later formed, secondary zoöids. The peribranchial tubes of the stolon segment into four pairs of peribranchial pouches. These, growing together posteriorly in each zoöid, form the atrium, the aperture of which appears later from an invagination of the outer ectoderm. The enteric tube likewise becomes constricted, but not completely so until quite late. From the enlarging pharynx cavity are formed several organs: the definitive endostyle, from an endostyle rudiment; a digestive tract, by evagination of the posterior (lower) side of the pharynx wall; the branchial chamber; and later the oral chamber and mouth, partly by the infolding of the outer ectoderm of this region. Gill-slits appear as elongated pores, always lying transverse to the endostyle; these are crossed by folds formed later across their inner surface (longitudinal bars). The nervous system arises from the ectoderm by invagination, as previously mentioned. The heart develops anew from a right, mesodermal cell strand very much as it does in the cyathozoöid. The remaining mesoderm passes into the stolon to give rise to genital and eleoblast tissue.

In the secondary ascidiozoöids the peribranchial pouches are derived, according to Seeliger, from the genital strand (mesoderm). According to this same author the neural rudiment also comes from mesoderm. But Neumann (1912) maintains that the peribranchial pouches and the nervous system arise from corresponding stolon-rudiments derived from the parent zoöid, hence they are probably ectodermal. In most other respects the development of the organs is similar in the primary and secondary ascidiozoöids.

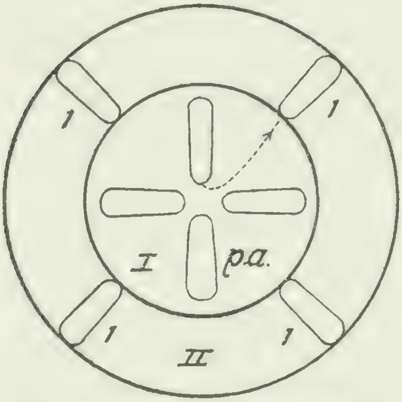

Fig. 8.—A diagram of an end view of a colony of Pyrosoma aherniosum, with the zoöids projected onto one plane.

The growth and formation of the colony has been deciphered by Seeliger and Neumann for *Pyrosoma aherniosum*, and to some extent for other species, as *P. verticillatum*. Each primary ascidiozoöid gives rise first to a single bud, and these buds move around to the left and occupy positions dorsal to the interspaces between the parent zoöids (No. 1, fig. 8). The next set of buds produced by the primary ascidiozoöids again move dorsally, this time occupying positions directly above the parent zoöids, and in the same whorl with the first formed four (No. 2, fig. 9). Thus far two rings, or tiers, of zoöids are established; an older one of four primary ascidiozoöids, and a younger one of eight secondary ascidiozoöids. Another set of four buds is again produced by the primary ascidiozoöids, these occupying positions above the interspaces between the secondary zoöids

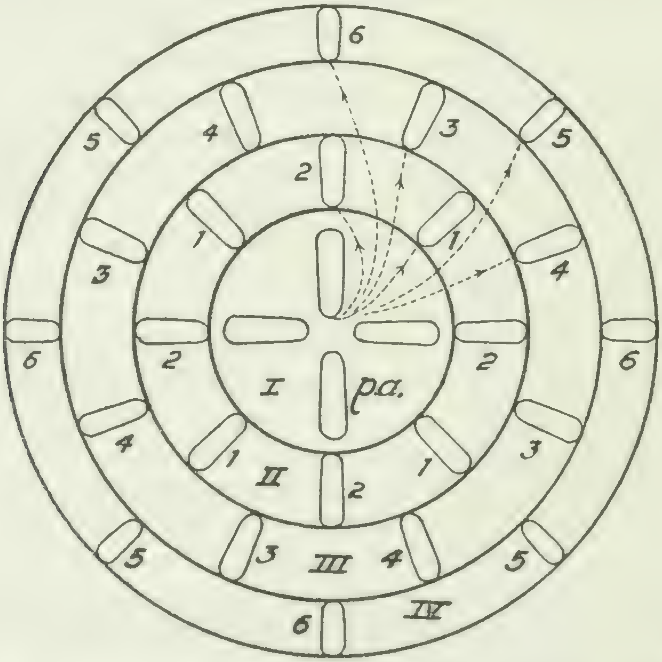

Fig. 9.—A diagram similar to figure 6, but illustrating an older colony.

of the second whorl, II (No. 3, fig. 9). In a similar manner a fourth set of four buds is produced (No 4, fig. 9), and the two sets (3 and 4) go to make up a third row (III). As many as seven or eight rows may thus be established, each row containing eight zoöids (*P. aherniosum*). At about this time, or sometimes earlier, the zoöids of the second row begin to bud, then those of the third and fourth rows, and so on. These later buds also migrate toward the open end of the colony and occupy the interspaces between the zoöids of the original transverse rows, establishing secondary rows. In this way the regularity of arrangement of the zoöids tends to be lost; in some species the transverse rows persist, but in others they disappear early.

The conditions of colony-formation thus far described, are those observed in the *Pyrosomata ambulata*. In the species *P. agassizi* and *P. spinosum*, on the other hand, the buds do not migrate freely through the test, so far as is known. Buds are produced in chains of three or four, or even as many as seven, individuals. These tend to move away from the parent zoöids and from each other, probably through the growth of the cellulose test separating them. From the first, the arrangement of the zoöids in these colonies is irregular. Large colonies of *P. spinosum* have been observed, however, in which the zoöids form longitudinal rows.

Subgenus PYROMOSOMATA FIXATA.

The *Pyrosomata fixata* are sufficiently distinct from the *Pyrosomata ambulata* to justify recognizing both as genera, but in this paper we have chosen arbitrarily to treat the two groups as subgenera.

The method of budding, so far as it is now known, is sharply distinct in the two subgenera. It has been taken by Neumann (1909–13) as a basis for naming the two groups. Among the *fixata* the buds form by the constriction of a proliferating stolon, produced at the posterior tip of the endostyle. As soon as one has been formed as a definite bud at the tip of the stolon, others form successively between it and the parent zoöids. There is formed thus a chain of several small buds of different sizes, as many as 7 having been observed in *P. spinosum*. The buds do not separate until comparatively late, and there has been observed no active shifting in their position, such as occurs in the *Pyrosomata ambulata*. Each takes its place ventral to the parent zoöids, so that in old colonies they show a semblance of regularity, lying apparently in longitudinal rows. It has not yet been determined just how the buds become distributed in the colony—whether the primary ascidiozoöids remain at the closed end of the colony, or around its aperture, all the buds taking positions ventral to them. Young colonies are needed for such study.

Each bud, when formed, sends out two tunic vessels from its dorsal side, which extend as far as the aperture of the colony. This is true of the secondary zoöids, but is true only of those which lie rather close to the aperture of the colony. The condition in the primary ascidiozoöids has not been determined.

Characteristics of the colony. The test is always of a soft and gelatinous nature, and ordinarily is transparent and colorless. The test processes are very characteristic of the group, being small, sharp, quadrangular spines, which always develop ventral to the zoöids and do not carry their oral apertures (fig. 6, pl. 18; fig. 3, pl. 16). There is no diaphragm at the colonial aperture, or only a rudiment of one. Some colonies bear four processes of the test projecting beyond and surrounding the colonial aperture (fig. 6, pl. 18).

The zoöids. The most striking feature in connection with the zoöids is the oblique position of the rows of stigmata in the branchial lamellae. This condition is very apparent in *P. spinosum*, (fig. 8, pl. 19), the stigmatal rows, instead of being vertical, having shifted over eighty degrees, until they lie almost parallel with the antero-posterior axis of the zoöid. In addition the branchial basket is broader in the direction of the stigmatal rows than at right angles to them.

The oral aperture bears several true tentacles (fig. 2, pl. 16), in addition to a median, ventral tentacle found in all *Pyrosomas* (fig. 13, pl. 22). The peripharyngeal bands come together at a sharp angle considerably posterior to the ganglion (fig. 5, pl. 17). Besides the luminous organs lying on each side of the pharynx, there are two other cell tracts, one on each side of the cloaca, near its ventral side (*l. ó.*, fig. 8, pl. 19), which probably have a similar function. There is no blood-forming organ on the dorsal side of the body, but Neumann (1909–13) believes that it is represented in this group by a mass of mesoderm cells lying around the digestive tract.[1] The endostyle is rather large in the members of this group, and shows histological features which, though characteristic, are not mentioned here, because they are of little taxonomic interest.[2]

In connection with the nervous system (pl. 16, fig. 2, and pl. 17, fig. 5) there should be noted the relatively large size of the ganglion, the slightly longer duct of the sub-neural gland (fig. 4, *A*), which opens directly beneath the ganglion, and the distribution of the nerves. This last is characteristically different in the two subgenera, as may be seen by comparison of figures 5 (pl. 17) and 13 (pl. 22). The first, second, fifth, and seventh nerves are the more prominent. Each of the peribranchial (cloacal) muscles is innervated by a prominent unbranched nerve, the seventh, while the fifth nerve goes to the cloacal sphincter, and the eighth, reduced in size, goes to the stolon process of the bud. In other respects the distribution of the nerves is somewhat similar in the two subgenera.

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[1] Compare *Salpa virgula*, aggregated zoöid. (Metcalf and Bell, 1918.)

[2] For details of the structure of the endostyle, and figures of same, see Neumann (1909–13).

The cloaca is diverse in size and shape (fig. 3, pl. 16; fig. 8, pl. 19). Its aperture is broad and bears on its dorsal edge a flat tapering languet (cloacal tentacle). The cloacal sphincter is incomplete, being broad and well developed on the dorsal edge, and lacking on the ventral edge (fig. 8, pl. 19).

Tle musculature is unique in some respects (figs. 2 and 3, pl. 16; fig. 8, pl. 19). The pair of muscles found one on each side of the cloaca in the *Pyrosomata ambulata*, are represented here by similar bands, but lying over the peribranchial spaces, near their middle. A variable number of branching and anastomosing muscle fibers surround the oral sphincter. Between the mouth and the ganglion, and between the mouth and the endostyle, are muscle fibers which branch on each side of the body. These constitute the lateral muscle system, which is peculiar to this group of the Pyrosomas.

Gonads. The testis forms between the stomach and the intestine (fig. 9, pl. 20; fig. 4, pl. 17), and consists of numerous, short lobes radiating toward the ventral side of the zoöid. The egg lies posterior to it. The large embryo is detached from the parent relatively early. Zoöids protandrous.

PYROSOMA AGASSIZI (Ritter and Byxbee, 1905).

Plates 16, 17, 18, and fig. 42, plate 33.

This species was first described from material taken from the Pacific Ocean. Subsequently it has been reported from the Atlantic and Indian Oceans. Our specimens come from the Pacific. We have seventeen in all, from ten different stations, and these agree very closely with the original description of the species. Some are preserved in alcohol, others in formalin.

The colony is rather long and slender, and is always limp because of the soft, gelatinous nature of the test. The test itself is very transparent, the zoöids being rather opaque. They are yellowish in the colonies preserved in alcohol, whitish in the formalin specimens. Usually there are present, at the open end of the colonial tube, four rather large processes of the test which are of variable length, and are quadrangular in cross section (fig. 6, pl. 18). One angle is toward the colonial aperture, one is on the opposite side, and two are lateral. The outer and the lateral of these ridges continue back onto the surface of the colony, which bears generally twelve ridges near its open end. Toward the closed end of the colony the arrangement of the ridges is less regular, instead of twelve, ten or less being found. Some of our colonies have the ridges less marked. The ridges at the closed end of the colony and those at the open end are for the most part not directly continuous, the arrangement over the middle of the body being confused by the interruption of most of the ridges and the suppression of others. In some of the larger specimens the processes at the open end of the colony are entirely lacking. It may be that we have here a retrograde variety characterized by the absence of these processes. In addition to the ridges, there are always present on the test the small quadrangular spines so characteristic of members of this subgenus (fig. 6, pl. 18). If anything, they are a little less numerous than in *P. spinosum.* On some colonies they are rather inconspicuous; the largest reach 5 mm. in length (Ritter and Byxbee). The relative dimensions of the colony do not vary widely. Small colonies are more fusiform, or taper more toward the closed end, than do large ones. All our preserved specimens are flattened except for one or two very young colonies. We can not be at all certain whether this flattening is natural or due to collapsing in preservation because of the extreme softness of the test. The colony is described as cylindrical by Ritter and Byxbee, who state that the diameter of a 12 cm. colony is about 1 cm. Our larger specimens do not exceed 8–11 centimeters in length, and this seems to be the maximum length attained by the majority of specimens of this species, according to other writers (*see* Neumann, 1909–13, p. 13), but since no colonies of this species bearing sexually mature zoöids have been reported, larger specimens may be found. Possibly at the time of sexual reproduction this *Pyrosoma* lives customarily at considerable depth.

The zoöids are arranged in the test irregularly (fig. 42, pl. 33). It is possible that they assume a more regular arrangement in longitudinal rows in the oldest colonies, as this is the case in the nearly related species, *P. spinosum.* The dimensions of our largest zoöids, in each of which is visible a small mass of cells between stomach and intestine, probably the forerunner of the testis, are as follows: length, as measured from the mouth to the atrial aperture, 2.5 mm.–3.2 mm.; height, measured dorso-ventrally at right angles to the longitudinal axis, 2.5 mm.–3.5 mm. From these figures it will be seen that the zoöid is higher than long. This appearance is emphasized by the fact that the disproportionate height of the branchial basket is even more marked, it being elliptical with the greater axis vertical. The oral and cloacal chambers are very much reduced. The rectum opens almost directly into the common colonial chamber because of the shallowness of the cloaca.

The mantle is a thin, delicate lamella in which the cell layers, ectoderm, endoderm, and mesoderm can scarcely be distinguished, so intimately are these fused together. The muscles associated with the mantle may be roughly assigned to three systems more or less independent of each other. Those of the oral region consist of an oral sphincter, and outside of this a variable number, three or four, of anastomosing circum-oral fibers. These latter are generally not present in young zoöids (fig. 7, pl. 18),[1] hence they seem to be of secondary development. In the lateral muscular system one finds ordinarily one ventral cross-strand in front of the endostyle (*l. m.*) and a dorsal set of about three strands just in front of the ganglion (*l. m'.*). The ventral strand branches once on each side of the zoöid; the three dorsal strands may branch once or twice on each side. In many of the older zoöids there is but one transverse band on the dorsal side, and this does not branch greatly (fig. 3, pl. 16). The fact that in this species the lateral muscular system is less developed in many adult zoöids than in the buds, and the further fact that this system is always still more developed in *P. spinosum*, indicate that, as regards the lateral muscles, *P. agassizi* is secondarily simplified. The branches from the two sets of fibers do not unite distally, as in *P. spinosum*. There is often a connection, however, between the dorsal portion of the lateral musculature and the circum-oral rings, by means of two connecting fibers, one on each side of the zoöid (fig. 3, pl. 16). The cloacal muscles, one lying on each side of the pharynx, over the peribranchial chamber, are rather long and slender (fig. 3, pl. 16). The dorsal end of each is connected with the ganglion by a prominent unbranched nerve, the seventh (figs. 3, pl. 16, and 5, pl. 17). There is a cloacal sphincter which is developed rather strongly on the dorsal side of the aperture but scarcely at all on the ventral side (fig. 3, pl. 16).

The pharynx. The oral aperture opens almost directly into the branchial chamber proper. It is relatively wide and bears a prominent fringe of true tentacles, these being fairly constant in number. There is one median tentacle which is the longest, and 16 to 18 others, arranged in most cases with an appearance of bilateral symmetry (fig. 2, pl. 16). The branchial chamber proper is broad and elliptical. The endostyle curves strongly near its anteroventral end. The dorsal languets, about 5 or 6 in number, commence just at the posterior termination of the peripharyngeal bands and continue back to the esophagus (fig. 7, pl. 18). They are fairly long but never very prominent. There are about 16 branchial bars, occasionally as many as 17, and from 20 to 31 stigmatal rows, usually 26. The stigmata in this species, instead of lying at right angles to the longitudinal axis of the zoöid, are so placed as to form an angle of 50° to 70° with this axis; that is, the stigmatal rows run from the antero-ventral side of the animal upward obliquely toward the postero-dorsal side. In the following species (*P. spinosum*) this angle is even smaller, 5°–20°.

Luminous organs (*l. o.*). These are best seen in young, actively growing colonies. They are variable in size and shape, usually quadrangular or elliptical, and are not at all prominent. As the zoöids grow older the cells composing them become scattered and in some instances disappear.

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[1] See to the contrary Neumann, 1909-1913, p. 92.

Nervous system (figs. 2, pl. 16, and 5, pl. 17). The ganglion is rather prominent. The distribution of the nerves connected with it is characteristic of the subgenus, as above described. The duct of the subneural gland bends downward strongly before opening into the pharynx (fig. 4 *A*, p. 206).

Digestive tract. The esophagus, a short funnel-shaped tube, enters the stomach posteriorly near its middle (figs. 3, pl. 16, and 4, pl. 17). In consequence of this peculiar juncture, the stomach has a cloven or bilobate appearance. The intestine is rather wide and forms an evenly curved loop, the oval anal opening lying opposite to the dorsal end of the stomach on the left side. The digestive gland is by no means conspicuous in this or in the following species (*P. spinosum*). Over the gut it presents a few small ridges, which converge to form the common duct of the gland.

As before mentioned, the cloaca is very broad and short. Its aperture is rather broad also, circular in outline, or broadly heart-shaped (fig. 4, pl. 17). There is a tentacle on its dorsal edge in large zoöids; in the immature zoöids this is represented by a small thickened prominence, or papilla, which shows the origin of the tentacle (see figs. 3, pl. 16, and 7, pl. 18). This tentacle is flat and triangular, and tapers to a narrow point when fully grown; its maximum length about equals the width of the atriopore.

Gonads have not previously been observed in *P. agassizi*. In the zoöids of one of our colonies we find what we take to be the developing testis (fig. 4, pl. 17). It lies between the two limbs of the digestive tract, and consists of a number of indistinctly demarcated groups of cells, which give a vague appearance of radiating from the central mass. No duct could be discovered leading away from it. The egg was not found, hence we are led to believe that some of the zoöids, at least, are protandrous.

Occurrence and distribution. *P. agassizi* is known to occur in the southern Atlantic, Indian, and Pacific Oceans. It seems to be most abundant in the Pacific.

Specimens of *Pyrosoma agassizi* were obtained at the following dredging stations during the *Albatross* Philippine Expedition, 1907–1910:

D. 5126, Nogas Islands, Sulu Sea, vicinity of southern Panay; Feb. 3, 1908; 742 fathoms; surface temperature 80° F.; one specimen, Cat. No. 6488, U.S.N.M.

D. 5233, Limasaua Island, between Bohol and Leyte; May 7, 1908; 15 fathoms; surface temperature 84° F.; surface density 1.02531; one specimen, Cat. No. 6422 U.S.N.M.

D. 5320, China Sea, vicinity of Formosa; Nov. 5, 1908; 1,804 fathoms; surface temperature 80° F.; one specimen, Cat. No. 6423 U.S.N.M.

D. 5378, Mompog Island; Mar. 4, 1909; 395 fathoms; one specimen.

D. 5458, Legaski Light, east coast of Luzon; June 7, 1909; 200 fathoms; surface temperature 85° F.; one specimen.

D. 5498, Bantigui Island, between Leyte and Mindanao; Aug. 3, 1909; 960 fathoms; surface temperature 82° F.; one specimen, dried out.

D. 5514, Camp Overton Light, vicinity northern Mindanao; Aug. 8, 1909; 697 fathoms; surface temperature, 83° F.; one specimen, Cat. No. 6489 U.S.N.M.

D. 5543, Tagolo Light, vicinity northern Mindanao; Aug. 20, 1909; 162 fathoms; surface temperature 84° F.; one specimen, Cat. No. 6424, U.S.N.M.

D. 5607, Binang Unang Island; Gulf of Tomini, Celebes; Nov. 18, 1909; 761 fathoms; surface temperature 83° F.; one specimen, Cat. No. 6512 U.S.N.M.

D. 5214, East of Masbate Island, Philippine Islands; April 21, 1908; surface; surface temperature, 81–82° F.; surface density 1.02475; two specimens, Cat. No. 6618, U.S.N.M. These specimens we have not had for study.

D. 5518, northern Mindanao and vicinity, Philippine Islands; Aug. 9, 1909; surface; surface temperature, 85° F.; one specimen, Cat. No. 6617, U.S.N.M. This specimen we have not had for study.

Three specimens Cat. No. 6499, U.S.N.M. were also obtained at *Albatross* station D. 3388, latitude 7° 06′ N.; longitude 79° 48′ W. off the Pacific coast of Panama; March 9, 1891; 1,168 fathoms; surface temperature 73° F.

Characteristic specimens of this species are found in the United States National Museum Collections, Cat. Nos. 6422, 6423, and 6424.

PYROSOMA SPINOSUM (Herdman, 1888).

Plates 19, 20, and fig. 11, plate 21.

This species was the first of its subgenus to be discovered. Its unique character seems to have been overlooked to some extent until later studies showed that it was organized upon a somewhat distinct plan. In fact, it has been proposed by some writers to place this species and *P. agassizi* together in a different genus from other Pyrosomas. The studies which have previously been made of this species were conducted chiefly upon Atlantic specimens, though Indian Ocean specimens have also been studied. We have two specimens from the Pacific, and one from the Atlantic Ocean, and in these we find a few new points of interest.

The colony. It is extremely difficult to secure material of this species suitable for describing the colony-form. Our specimens, like most of the others known, are fragmentary, in consequence of which the proportions of the colony cannot be determined. The colonies appear to be cylindrical for the most part, and to taper but slightly toward the closed end; more than this we can not assert. The test is soft, gelatinous and extremely flabby. It is colorless in our specimens. On its outer surface there are numerous quadrangular, or triangular, spines such as we described for *P. agassizi*, each one placed ventral to, and overarching the oral aperture of a zoöid, (pl. 19). Organs corresponding to the four elongated "tentacles" surrounding the colonial aperture in *P. agassizi*, have not with certainty been found in this species. Krüger (1912) has described as *P. agassizi* an Atlantic *Pyrosoma* which apparently is no other than *P. spinosum*. As described and figured we would have no hesitation in assigning it to the latter species, for it has the characteristic form of zoöid, somewhat immature, and the complex musculature, numerous stigmata, etc., peculiar to this species. But some of the colonies are described as possessing four processes of the test, surrounding the colonial aperture. We are uncertain whether this remark is meant to apply to Krüger's specimens, or to *P. agassizi* in general, according to previous descriptions. If the former is the case, it would indicate that some colonies of *P. spinosum* do bear these four processes. Since they have been found to be so irregular in occurrence in *P. agassizi*, it seems likely that they may be so in *P. spinosum;* that is, present in some cases, absent in others, or perhaps large in young colonies and sometimes absorbed in older ones. Farran (1906) reports *P. spinosum* from the North Atlantic Ocean, figuring the colony with four test processes around the colonial aperture, but no adequate description of the zooids is given. There is no colonial diaphragm. The size of the colony is in a way rather distinctive; that is, the largest colonies of *Pyrosoma* reported belong to this species. Bonnier and Perez (1902) found specimens in the Indian ocean of enormous size, the largest 4 m. long; others 2½ m. long, 20–30 cm. in diameter. The majority of the specimens collected, however, do not exceed 50 cm. in length.

Zoöids. An irregular arrangement of the zoöids in the test obtains in the younger colonies of *P. spinosum*. Large specimens have been found in which there is a fairly regular arrangement of the zoöids in longitudinal rows, those in one row occupying alternate positions to those in the adjacent rows (Herdman, 1888). Rather characteristic of this species is the thickness of the test wall, and coordinated with this, the extraordinary length of the zoöids. Mature individuals, from medium-sized colonies, measure 0.8 cm.—1 cm. in length from the mouth to the base of the cloacal tentacle. The largest ones known are fully 2 cm. long (*see* Neumann, 1909–'13). They are about 3 mm. to 4 mm. in width. We find in our specimens that the ventral side of the zooid is directed toward the closed end of the colony, as we might expect, a point not definitely ascertained by other workers, on account of the poor condition of their material.

The mantle is thin and delicate.

The musculature is fundamentally similar to that in *P. agassizi*, but is much more highly developed (pl. 19). The fibers of the lateral muscular system are numerous and complexly interwoven. The dorsal portion, consisting of 8–10 long branches, is connected distally on each side of the animal, by two or three strands, with the ventral portion, which has about 4 branches. Some of the dorsal fibers are fused with the thick cloacal muscle. Around the oral aperture, outside of the sphincter, are an indefinite number of circum-oral fibers which are simple on the ventral side, but dorsally branch and anastomose freely with each other and with the oral sphincter. Their maximum number is 7 or 8. The cloacal muscle, over the peribranchial region, is short and thick. It runs nearly parallel with the long axis of the colony. An atrial sphincter is present on the dorsal edge of the cloacal aperture as a broad band. It does not extend more than halfway around on each side of the aperture.

In this species the prebranchial chamber is more prominent than in *P. agassizi*, but is never prolonged into a siphon. The oral aperture is a little sunken beneath the surface of the test. It bears a circle of long tentacles, about 15 in number, of variable size, the median ventral one longer than the rest.

The branchial chamber proper is a greatly elongated cavity, whose stigmatal rows lie at an angle of about 10° to the longitudinal axis of the zoöid. It is elliptical in contour and a trifle narrower at the anterior than at the posterior end. Each of the delicate branchial lamellæ bears about 55 narrow stigmatal rows and a large number of bars, 30–44, which in this species run nearly transverse to the principal axis of the zoöids. The anterior third of the endostyle is curved sharply around the front of the pharynx, so that this portion of it really bounds the anterior end of the zoöid. From its forward end the peripharyngeal bands pass diagonally toward the ganglion, continuing distinct posterior to it for quite a distance. At the point where they unite the dorsal languets commence. There may be as many as 22 of these (Neumann). We find in our Pacific specimens only 9 or 10, all rather long and slender and inconspicuous.

The luminous organ is a small indistinct group of cells, of oval form, lying over the peripharyngeal band and very near to the endostyle. Luminous organs also are found on each side of the cloaca, near the ventral end of its aperture (*l. o'.* in figs. 8 and 9). They are in the form of thin groups of loosely arranged cells.

The ganglion is egg-shaped. The duct to the ciliated funnel turns sharply backward before making connection with the wall of the pharynx.

Digestive tract. This "nucleus" of organs is so placed that its elongated axis is more nearly parallel to that of the zooid than in any other *Pyrosoma*. The rotated position of the pharynx seems to account for this. We find also that the intestine is greatly elongated, the anus being located considerably posterior to the stomach. The esophagus opens from the pharynx, between the posterior ends of the stigmatal rows, by a broadly funnel-like aperture. It enters the posterior side of the stomach, giving to this latter organ its broad, bilobed appearance (fig. 9, pl. 20).

In the region just anterior to the gut, the proliferating stolon develops (*s.*, fig. 8). Between the base of the stolon and the endostyle one can sometimes observe an elongated tube, the pericardium, with a dorsal invagination, the heart.

The gonads can be found in the zooids of comparatively large colonies only. The testis, composed of a large number of radiating segments (we counted as many as 77 in one case), is a flatly hemispherical body lying posterior to, and between, the two limbs of the gut. A sperm duct takes its origin on the upper (inner) side of the testis and, passing back beneath the intestine as a dilated tube narrowed at its distal end, it opens into the cloaca. At the edge of the cloaca, and very near to the aperture of the sperm duct, the egg is attached (*ov.* fig. 8). This lies in a vescicle formed by the inner and outer layers of the cloacal wall. Embryos were found of rather large size, 1.5–2 mm. (fig. 11, pl. 21), but in only a few had the formation of the four primary ascidiozoöids more than commenced. The embryos, whose stolons have segmented into four zoöids, are much smaller (0.6 mm.), having the yolk mass greatly reduced. It would seem that this loss of volume of the yolk mass can not be due solely to its having been used as food, but that it must have lost bulk also by osmosis. All of these embryos were detached from the parental ovaries. From this fact, and because of their large size, it seems probable that they are customarily sent out of the colony at a very early period in their development. The species is strongly protandrous. In zoöids in which the testis has developed into a very well-defined organ, with a duct, the egg has often just made its appearance; and in maturer zoöids, in which the egg is ripe, the testis may be undergoing degeneration. This relation, of protandry in the zoöid does not preclude the possibility of self-fertilization within the colony, for the various zoöids mature at different periods.

In our material from the Pacific Ocean we find an organ of problematic function, which may possibly have something to do with reproduction. It is a reniform, vesiclelike organ attached by its end to the outer surface of the body near the ventral edge of the cloacal aperture (figs. 9 and 10, pl. 20).

The *cloaca* in *P. spinosum* is very greatly modified, perhaps in adaptation to the oblique position of the pharynx and digestive tract. Its dorsal wall is greatly elongated, the ventral one much shorter, and as a result of this the aperture opens obliquely ventrally, that is, in the direction of the closed end of the colony. We find this to be true on examining the zoöids in place in the colony, although the test projects so far beyond the edges of the cloaca that it quite obscures the real direction of the opening. A long, sharp tentacle surmounts the dorsal rim of the cloacal opening. In length (2–3 mm.) it may exceed the breadth of the aperture.

Occurrence and distribution. The species is found in the Atlantic, Indian, and Pacific Oceans. Our specimens are the first ones reported from the Pacific Ocean; there are two of these, both from the vicinity of the Philippine Islands.

Specimens of *Pyrosoma spinosum* were obtained by the *Albatross* during the Philippine Expedition of 1907–1910, as follows:

D. 5613, Buka Buka Island, Gulf of Tomini, Celebes; November 20, 1909; 752 fathoms; surface temperature 84° F.; one specimen.

D. 5631, Dowarra Island, south of Patiente Strait; December 2, 1909; 809 fathoms; one specimen, Cat. No. 6407, U.S.N.M., also Cat. No. 6630, including 50 or more zooids from the same specimen as Cat. No. 6407.

One specimen, Cat. No. 6406, U.S.N.M., off the Massachusetts coast at station D. 2228, latitude 37° 25′ N., longitude 73° 06′ W.; September 11, 1884; 1,582 fathoms; surface temperature 77° F.

It seems probable that *P. spinosum* attains a larger size in the Atlantic than in the Pacific Ocean; and it seems certain that Pacific specimens come to sexual maturity earlier. Krüger (1914) found no gonads in the specimens which he describes as *P. agassizi*, but which we take to be *P. spinosum*. His largest colony was over a meter in length and about 10 cm. in diameter. Our largest Pacific specimen is not more than 5 cm. in diameter (dimension of a fragment), yet its zoöids contain mature gonads and well-developed embryos. According to other descriptions, there have been no embryos found in Atlantic specimens of this species, although colonies of over one meter in length have been reported. The very large colonies (4 m.) from the Indian Ocean (Bonnier and Perez, 1902) were not closely studied in this connection. It is natural to ask, is this difference in size due to environmental conditions affecting growth (temperature, abundance of food, and the like), or can it be that there are two races of this species.

Subgenus PYROSOMATA AMBULATA.

Budding. The production of buds is accomplished as in the *Pyrosomata fixata*, by means of a proliferating stolon formed at the posterior end of the endostyle (fig. 30, pl. 26 and fig. 32, pl. 27). Only one bud is produced at a time, for as soon as one has formed it is set free and a new bud develops from the remainder of the stolon. After separating from the parent zoöid the young bud is moved dorsalward or toward the aperture of the colony, through the agency of special test cells given off from the dorsal side of the bud. These wandering buds take positions dorsal to the next older tier of zoöids. In young colonies they arrange themselves symmetrically,[1] coming to lie opposite the interspaces between the parent zoöids (figs. 50, 52, and 53, pl. 36). Some species preserve this regular arrangement (figs. 43 and 44, pl. 33); others lose it, usually rather early (pls. 34 and 35). A result of this manner of colony formation is that the four primary ascidiozoöids remain at the closed end of the colony, new buds continuing to form around the open end of the colony until a certain stage is reached (see p. 212).

There are two tunic vessels developed in connection with each primary ascidiozoöid, but only one from each of the subsequently formed buds.

The colony. The test is generally of rather firm, cartilaginous texture. It is transparent, usually colorless, but sometimes a little stained, probably from pigment contained in the zoöids. There are no "guarding" processes of the test surrounding the colonial aperture, but a diaphragm is generally present and well developed (fig. 46, pl. 34). Many species have test-processes over the general surface of the colony, in the form of conical protuberances, through which the oral siphons of the zooids project so as to open near their outer ends (pls. 34 and 35; fig. 24, pl. 24; fig. 26, pl. 25; fig. 30. pl. 26). Sometimes the general surface of the test is denticulate or roughened.

Zoöids. The rows of stigmata are not oblique, but run at right angles to the longitudinal axis of the zoöid. In most cases the branchial basket is elongated in the direction of this axis. The oral aperture bears a median, ventral tentacle, and a rather definite number of tentacle-like folds or swellings, forming a circlet around its inner border (fig. 13, pl. 22). The prebranchial chamber may be short (pl. 23) or be elongated as an oral siphon (fig. 26, pl. 25). The peripharyngeal bands unite at a broad angle directly beneath the ganglion (fig. 13, pl. 22). A single pair of luminous organs, at the side of the peribranchial chamber, is always present. The blood-forming organ is present as a conspicuous, elongated mass of cells on the dorsal side of the zoöid.

Nervous system. In this subgenus the ganglion is smaller (fig. 13, pl. 22). The duct of the subneural gland runs obliquely forward from the ganglion (fig. 4 *B*, p. 206), and is shorter than among the *Pyrosomata fixata*. An idea of the distribution of the nerves may be gained from figure 13. It will be seen that the fourth and sixth nerves are least prominent. The cloacal muscle is innervated by the fifth and, in part, by the eighth nerve, the atrial sphincter by the seventh, the last pair (eighth) being large and important.

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[1] See Neumann, 1909, c and 1909–1913, for a fuller account.

The pigment cells, found to some extent in the zoöids of all *Pyrosomas*, are sometimes quite conspicuous in the members of this subgenus. In some species they occur in masses on the viscera; in others, as large, star-shaped cells scattered over the walls of the prebranchial or of the cloacal chamber (fig. 25, pl. 24).

The cloaca may be short and broad (fig. 17, pl. 23), but ordinarily it is elongated, and has a small, circular aperture (pl. 29).

Two cloacal muscles (*cl. m.*) lie one on each side of the common cloaca (pls. 30 and 31). There is no lateral muscle system, as in the *Pyrosomata fixata*, but there are two or three circumoral fibers, which do not branch and anastomose (pls. 26 and 27). Oral and cloacal sphincter muscles are present as simple, closed rings (fig. 36, pl. 29).

The gonads occupy positions ventral to the digestive tract, and generally quite distinct from it. The testis lies on the left side, the ovary on the right (fig. 31, pl. 27); both develop at about the same time, or one in advance of the other (protandry or protogyny). There are relatively few (12–30) lobes in the testis, and these project inward. The embryo is retained in the ovary until fairly late in its development. When released, it continues its growth in the cloaca, in those species in which the cloaca is large, or in the right peribranchial space, if the cloaca is short. The majority of the forms are rather small, hence mature their sexual products relatively early.

PYROSOMA VERTICILLATUM (Neumann, 1909, c).

Plate 21, fig. 12; plate 22, fig. 13.

This species was first taken from the Indian Ocean (Feb.–Mar., 1899, Deutsche Tiefsee-Expedition). Twenty-one colonies in all were collected, and have been described as representing a distinct type of *Pyrosoma*. They were characterized by their unique form, but more especially by the regular arrangement of zoöids which obtains, even in adult colonies.

Specimens taken by the *Albatross* in Philippine waters in 1908–1909, though undoubtedly belonging to this species, yet appear to differ from those described by Neumann. Since these points of difference are constant throughout the entire *Albatross* collection—of twenty specimens from five stations—it has seemed best to treat this new type as a variety of the present species. In variety *cylindricum*, as we name it, the colony is relatively longer—that is, more slenderly cylindrical—and there are numerical distinctions—as regards number of stigmata, and the like—to be described later.

The colony of *P. verticillatum* is typically egg-shaped, occasionally somewhat elongated. The largest is but 3 cm. long, so that it is probable that this form reaches a definitive length seldom exceeding 2.5 cm. The zoöids are arranged in transverse, parallel rows, or verticils; the spaces between the zoöids and also between the rows are relatively great. Test-processes are completely lacking, and the test itself is firm, smooth, transparent, and colorless. The oral apertures are considerably sunken beneath the surface of the colony, so that there is a funnel-like depression in the test leading down to each.

Mature zoöids are 2.5–2.7 mm. long from mouth to cloacal aperture, 2.7–3 mm. high, i. e., in dorso-ventral measurement. They vary only slightly in size throughout the colony. The branchial basket in this form is quite short and is relatively simple in its make-up. There are about 21 dorso-ventral rows of stigmata on each side of the branchial chamber, and about 11 longitudinal bars. Dorsal languets, 4–5. There is only a very short cloacal chamber, the two peribranchial pouches opening almost directly into the colonial cavity by the very wide atrial opening. The cloacal muscle is long and narrow.

Gonads. The testis is described as consisting of from 12 to 15 lobes, lying rather more on the posterior than on the ventral wall of the body, and scarcely bulging beyond the general contour of the body. The egg is said by Neumann to mature earlier or sometimes later than the testis. This statement is based upon his own and upon Seeliger's observations, namely, that even in those species whose zoöids are ordinarily strongly protogynous, the four primary ascidiozoöids, and a few of the later formed zoöids, may ripen their spermatozoa first. Protogyny within the individuals of the colony seems to come about progressively from an original condition of protandry as new zoöids are formed by budding. Thus the possibility of self-fertilization in this species (considering the colony as the individual) is not precluded. Nevertheless it should be strongly emphasized that in this and some of its nearly allied forms, protogyny is the rule for most of the zoöids within the colony. In others, to be described later (as subspecies of *P. atlanticum*), there is even an approach to a condition of protandry in many zoöids. For the most part the male and female sex-cells in the zoöids of *P. atlanticum* and its several subspecies ripen at nearly the same period, although here also there is progressive maturing of the sex-cells from one end of the colony to the other.

The characteristics of *P. verticillatum* are given by Neumann as follows: the funnel-like oral depressions in the otherwise smooth surface of the test, the height (dorso-ventrally) of the zoöids, the position of the testis on the posterior rather than the ventral body-wall, and especially the arrangement of the zoöids in regular transverse whorls.

P. verticillatum is found in the Indian Ocean, where it was collected first southwest of Ceylon, and again shortly afterwards west of the Chagos Archipelago. It is reported also from the Pacific Ocean, although it is probable that the Pacific specimens, if restudied, might have to be referred to the variety (*cylindricum*), which is found in these waters. The species is by no means abundant, to judge from the paucity of specimens obtained, hence it is not so well known as others.

PYROSOMA VERTICILLATUM CYLINDRICUM, new subspecies.

Plate 22, figs. 14 and 15; plate 33, fig. 43.

The form here considered is represented, as before mentioned, by 21 specimens taken during the Albatross Philippines Expedition (1908–1909).[1] As these differ in several particulars from the species just described, and since these distinctions are more or less constant, it seems quite possible that we have here a geographical race or subspecies confined to the Pacific Ocean.

The cylindrical form of the colony is in contrast to the more ovate form of *P. verticillatum*. As in *P. verticillatum*, a regular arrangement of zoöids obtains, even in the mature specimens. The largest colonies attain a length of 3.4 cm., the majority, however, about 2.5 cm. The width or thickness of the cylindrical trunk averages 1.2 cm. The test is very much like that of *P. verticillatum*—firm, colorless, transparent, and smooth except for the funnel-like depression over each oral aperture (fig. 15).

All the larger zoöids—those which have taken up a definitive position in the test—appear quite globular and short (fig. 15). In size these range between 2.2 and 2.4 mm. in length, averaging 2.4 mm. in height (dorso-ventrally). These vary little in size or form or in the character of their organs. There are always numerous small zoöids around the colonial aperture, those which have been formed most recently as a result of budding.

The atrium is very short and broad; the oral chamber—i. e., the portion of the pharynx in front of the stigmata—is almost lacking. On this account the zoöids, examined in side view, appear circular to quadrangular in outline. This appearance is emphasized by the height of the branchial basket, which is higher than long. In the better-known species, described below, the zoöid is elongated, often greatly so.

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[1] United States National Museum. Cat. Nos. 6468 (type), 6412, 6413, and 6414. The authors much prefer the Latin form "*typus*" in taxonomic reference, but they conform to the editorial usage of the United States National Museum.

The mouth and its associated parts are simple, probably affording typical conditions for the subgenus, since there appear to be no muscles or nerve fibres which have become modified through overgrowth or atrophy. The inner border of the mouth is fringed with a variable number (usually 18) of small folds erroneously called tentacles; and on the ventral edge there is a median tentacle with a vesicle-like enlargement at its base. The whole constitutes what Huxley called the "tentacular fringe." Surrounding the mouth and fringe there is an oral sphincter muscle, and outside of this two delicate, circum-oral fibres. The nerves about the oral region are rather easily traced and identified.

The branchial basket shows about 14 longitudinal bars on each side, and from 27 to 28 rows of stigmata. This serves to distinguish this variety from *P. verticillatum* proper, in which the number of bars is about 11, and the stigmatal rows about 21. The number of the dorsal languets, five, seems to be constant in adult individuals. The endostyle is typical but short, making a strong, even curve along the ventral side of the pharynx. The digestive tract appears very narrow; the intestine makes a sharp bend upon itself instead of the wider, customary loop (see *P. atlanticum atlanticum*). The two dorsal leucocyte masses are distinct from each other. They are short and not very conspicuous. The luminous organs are usually oval and elongated dorso-ventrally.

The reproductive organs bear about the same relation to the zoöid as is characteristic of the species type. The testis causes the posterior wall of the body to bulge somewhat, often projecting considerably. Its lobes, about 15 in number, are directed nearly forward, or diagonally forward and upward; they rarely form a compact organ but lie rather open, and in the form of a rosette. As before mentioned, the cloaca is very short and broad. Its aperture is also broad, there being scarcely any diaphragm, so common in other Pyrosomas. Correspondingly we find the cloacal muscle long and narrow. The ovary lies to the right of the testis as usual, developing ordinarily much before the latter, so that the zoöids would be described as protogynous. In agreement with the observations of Neumann upon *P. verticillatum*, we find that in the variety *cylindricum* the primary ascidiozoöids and the earlier formed buds may be protandrous; at least the testis makes its appearance first in the early zoöids of this variety.

Embryos in the four primary zoöid stage, tetrazoöid colonies, or "Viererkolonien," were found in the right peribranchial spaces of several zoöids. Some, less developed, were still fixed in the wall of the cloaca. Embryos with unsegmented stolons measure 0.6–0.9 mm. in diameter; those with the stolon dividing into four zoöids are about 0.6 mm. in diameter. There is therefore no rapid shrinking in this embryo such as occurs in those of *P. spinosum*.

All the known specimens of *P. verticillatum cylindricum* are from the northern Pacific Ocean in the vicinity of the Philippine Islands, and were taken by the steamer *Albatross* during the Philippine Expedition of 1907–1910 at the following stations:

D. 5120, Sombrero Island, Verde Island Passage; Jan. 20, 1908; 393 fathoms; surface temperature, 43.7° F.; surface density, 1.02386; one specimen, Cat. No. 6414 U.S.N.M.

D. 5125, Nogas Island, Sulu Sea, vicinity southern Panay; Feb. 3, 1908; 411 fathoms; surface temperature, 80° F.; surface density, 1.02444; seven specimens, Cat. Nos. 6468 (Holotype) and 6412 (Paratype) U.S.N.M.

D. 5320, China Sea, vicinity of Formosa, Nov. 5, 1908; 1,804 fathoms; surface temperature, 80° F.; one specimen.

D. 5437, Hermana Mayor Light, west coast of Luzon; Apr. 9, 1909; 100–600 fathoms; surface temperature 86° F.; two specimens.

D. 5456, Utara Point, Bongo Island.; May 22, 1908; 158 fathoms; surface temperature, 86° F.; surface density, 1.02262; ten specimens, Cat. No. 5456 U.S.N.M.

PYROSOMA HYBRIDUM, new species.

Plate 36, figs. 54 and 55; plate 23, figs. 16 and 17.

This is a fairly distinct form, representing to some extent a condition intermediate between the preceding species and *P. ellipticum*. It is not likely that it is a hybrid form, for there have been collected a considerable number of specimens, 16 in all, from four localities. Moreover, there are certain characters peculiar to this species which serve to distinguish it from all nearly related species. It seems not unlikely, however, that such varieties as the present one may have arisen originally as the outcome of hybridization. Its nearest relative is *P. verticillatum*, but it seems a little too divergent to be properly classed as a variety of this species, especially as no intergrading forms are known..

The colony is laterally flattened in all cases, and appears oval when viewed from the side (fig. 54). The relative dimensions are somewhat variable: An average specimen is 2.4 cm. long, 1.7 cm. wide, and 0.4 cm. thick. Larger specimens—the largest is 4.2 cm. long—are relatively more narrow. The ratio of the width to the thickness of the colony is about 4 to 1. All the zoöids, and to some extent the test, are darkly stained bluish-gray, never yellow; the testes when mature appear as black bodies. A verticillate arrangement of zoöids in transverse whorls obtains here, as in the preceding forms. In all but the older specimens they display a progression in size from one end to the other of the colony, those near the diaphragm being small and closely packed together, and those at the closed end largest.

There are no processes on the firm test, and its surface is quite free from denticulation. The oral apertures of the zoöids are only slightly sunken (fig. 17).

The zoöids are longer than high, averaging 3 mm. in length, 2.5 mm. in height. The oral chamber, while distinct, is very short; sometimes it is quite lacking. The cloaca is also short, never exceeding about one-fifth the length of the branchial basket.

In details of anatomy this form very much resembles the preceding one. The branchial basket, however, is longer than high, and contains more stigmata and supporting bars. On each side there are from 14 to 15 longitudinal bars (or rarely 16), and 27 to 30 rows of stigmata. The dorsal languets number from 5 to 7. As has previously been described for *P. verticillatum*, so in this form, the endostyle is rather strongly and evenly curved; but in this species it is, in addition, slightly shorter than the branchial chamber. In the species to be described next this shortening is even more marked. There is nothing peculiar in the organization of the digestive tract. It appears narrow; the intestine is sharply bent upon itself. Ordinarily the cloacal muscles lie opposite the stomach—one on either side of it.

This species also is protogynous, that is a preponderance of individuals in the colony show a protogynous condition. The testis is a rather compact and roughly hemispherical body, consisting of about 15 lobes. When mature it lies in a distinct evagination of the postero-ventral body wall, and it may at this time attain to a considerable size (0.7 mm. in diameter). The egg usually develops somewhat earlier than the testis; advanced embryos, after becoming detached from the body wall of the parent, complete their development in the right peribranchial space. Occasionally these may be found in the left peribranchial chamber, or in the cloaca.

Distribution. All of our specimens of *P. hybridum* were collected in the western Pacific Ocean, in Philippine waters, by the *Albatross* during the years 1907–1910, at the following stations:

D. 5238, Port Lambajon, east coast Mindanao; May 12, 1908; 380 fathoms; surface temperature 86° F.; surface density, 1.02453; two specimens; Cat. No. 6493 U.S.N.M.

D. 5320, China Sea, vicinity of Formosa; Nov. 5, 1908; 1,804 fathoms; surface temperature, 80° F.; 11 specimens; Cat. Nos. 6470 (Holotype) and 6408 (Paratypes) U.S.N.M.

D. 5457, Legaspi Light, east coast of Luzon; June 7, 1909; 146 fathoms; surface temperature, 85° F.; two specimens; Cat. No. 6481 U.S.N.M.

D. 5458, Legaspi Light, east coast of Luzon; June 7, 1909; 200 fathoms; surface temperature, 85° F.; one specimen; Cat. No. 6486 U.S.N.M.

PYROSOMA ELLIPTICUM, new species.

Plate 23, figs. 18-20; plate 33, fig. 44.

A single, small colony of *Pyrosoma*, which differs in certain fundamental points from all other known forms, was taken by the *Albatross* from the China Sea on November 5, 1908. In general appearance, however, it does not seem to represent a sharply demarcated species. One of the characters which distinguish it is the nearly complete flattening of the colony as a whole, so that in side view it is oblong with rounded corners and in edge view more nearly linear. (See the end view, fig. 20, pl. 23.)

Other characteristics are the regular, but not strictly verticillate, arrangement of the zoöids in the test; and certain differences in the organization of the zoöids. All these characters of the zoöids are rather uniform and constant, and all the zoöids show about the same size. The measurements of the specimen studied [1] are as follows: Length, 4.5 cm.; width, 2 cm.; and mean thickness about 0.7 cm. The open end is somewhat broader than the closed, as we might expect. In correlation with the flattened condition of the colony, the opening into its axial chamber is slit-like (fig. 20). At both ends of the colonial aperature there is a broad expansion of the diaphragm which effectually preserves the shape of the aperture. Any attempt to pull the test into cylindrical form must result in a tearing of this diaphragm at the ends of the ellipse. Hence, it is not probable that the flattened form of the colony in our preserved specimens of this species is due to any collapsing from mechanical causes.

A close and rather uniform arrangement of the zoöids obtains. They lie in rows transverse to the long axis of the colony, but the whorls thus formed appear more obscure than in any of the verticillate forms yet described. The zoöids in one whorl lie generally opposite interspaces between the zoöids of the adjacent whorls, thus forming somewhat obscure longitudinal rows. The arrangement, however, is not perfectly regular. The oral apertures of the zoöids open flush with the outer surface of the test; hence there are no funnel-like depressions in its surface such as are found in *P. verticillatum*. The zoöids also appear more collapsed or flattened laterally. There are no processes or denticles on the test. In color the colony in alcohol is yellowish-brown, the test itself being very clear and transparent. The color is probably due in part to the test absorbing color from the pigment cells on the esophagus of each zoöid. In our preserved specimens all the tissues of the zoöids appear brownish and the test is yellowish. There is no sediment or débris in the zoöids or any part of the colony to cause color. The viscera of the zoöids appear as dark-brown, opaque bodies, especially the testes, which are of large size in this species.

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[1] Other specimens, doubtfully of this species, were taken in September, 1899, at a station 600 miles northward of the Marquesas Islands. (Station 3788—*Albatross*.)

The form of the zoöids as seen in side view is best described as oval, some individuals being quadrangular or some elongated. In size they vary from 2 to 2.6 mm. in height and from 3.2 to 4 mm. in length, the average conditions being 2.4 mm. high and 3.7 mm. long. It should be emphasized in this connection that throughout the colony there is very great uniformity as to the size of the zoöids. This is strongly in contrast to conditions found in the three preceding forms (*P. verticillatum* and its variety *cylindricum* and *P. hybridum*). The atrium in this form is of moderate length, i. e., from one-third to one-half that of the branchial basket. The oral or prebranchial chamber is rather short but never entirely lacking (fig. 18).

The mantle is fairly firm in texture. Associated with it are the muscles usual in the subgenus. These are the customary pair of cloacal muscles—rather long and narrow—, oral and atrial sphincters, and two circum-oral ring fibers.

The short prebranchial zone never exceeds one-fourth of the length of the branchial basket. The mouth is small and shows the characteristic "fringe" and ventral tentacle. The branchial basket is nearly oval in side view, with slightly truncated posterior end. On each side there are 16 longitudinal bars, occasionally only 15, and 27 to 28 stigmatal rows. The endostyle is peculiar in being shorter than the branchial basket. Dorsal languets, 6 to 7. The luminous organs are mostly oval. Each of the dorsal leucocyte masses is small and distinct. A description of the digestive tract would correspond very closely to that given for *P. verticillatum cylindricum* The stomach may be relatively larger, but is still rather narrow and rather square at the ends; the intestine is thicker and less sharply bent upon itself.

Gonads. In this species the zoöids are protogynous. The egg ripens early, and when considerably advanced in development, detaches itself from the cloacal wall and moves up into the right peribranchial space. The testis attains to a large size, and when mature is compact and globular, protruding strongly beyond the ventral body contour. It consists of about 18 finger-like lobes which are directed for the most part upward and slightly forward.

We see in this species, for the first time in this subgenus, an appreciable narrowing and likewise a lengthening of the cloaca. The reduced size of the atriopore is also characteristic, for although not so small as in some (*P. atlanticum* and its several subspecies) it is much more constricted than in the previously described members of this subgenus.

Distribution. This species is at present known only from the western Pacific Ocean, and was taken during the *Albatross* Philippine Expedition, 1907–1910, at the following stations:

D. 5319, China Sea, vicinity of Formosa; November 5, 1908; 20 fathoms; surface temperature 79° F.; one specimen (*Type*), Cat. No. 6416, U. S. N. M. Eastern Tropical Pacific Expedition.

H. 3788 (A.A. 15), latitude 4° 35′ N.; longitude 136° 54′ W.; 600 miles north of the Marquesas Islands; September 8, 1899, 2,583 fathoms; surface temperature 80° F., one specimen, Cat. No. 6425. U. S. N. M.

PYROSOMA OPERCULATUM (Neumann, 1908).

Plate 24, figs. 21–23.

Only one specimen of this interesting form has been collected. This was found in the Indian Ocean a little westward of the Chagos Archipelago (Deutsche Tiefsee-Expedition, Station 228). The colony is about 5½ cm. long and 3½ cm. broad. In form it is broad and cylindrical, roundly truncate at both ends, the closed end being somewhat broader than the open end, the shape of the colony being thus unique among the Pyrosomas. The surface of the test is quite smooth in this species.

The zoöids are closely and irregularly placed in the test. They attain a length of about 9 mm. The prebranchial chamber is of moderate length; it is encircled by two circum-oral muscle fibers. The branchial chamber in side view appears as a slightly prism-shaped box, narrowed behind, with straight sides, as the endostyle is not curved except at its extreme anterior end. There are about 40–45 rows of stigmata and 18–20 longitudinal branchial bars. Dorsal languets, about 16.

Gonads. The testis is composed of 15–17 tentacle-like lobes, and in their midst, a sperm duct with a dilated, spherical receptacle. It lies in an evagination of the body wall. This species is strongly protogynous. Growing zoöids, in which the embryo has reached the tetrazoöid stage of development, contain as yet only the rudiment of a testis.

The cloacal chamber is elongated and narrow, appearing three-cornered in cross-section. In young zoöids it may equal the length of the rest of the body, but in older ones it is relatively shorter—about one-half as long as the rest of the body. On the ventral border of the cloacal aperture there is a prominent, hood-like valve (figs. 22 and 23), which is found in no other species of *Pyrosoma*. The edges of the aperture are bordered by a narrow muscle band, probably identical with the cloacal sphincter in other forms. The function of this peculiar apparatus seems to be, as Neumann thinks, to prevent the water in the colonial chamber from flowing back into the pharynx of the zoöid while water is at the same time entering it from the mouth.

PYROSOMA AHERNIOSUM (Seeliger, 1895).

Plate 24, figs. 24 and 25.

The German Plankton Expedition found this species of *Pyrosoma* in the tropical regions of the Atlantic, where it appears to be not at all uncommon. Forty-eight colonies were collected, from nine different stations, by this expedition, while others have been found subsequently in the Indian Ocean. The species is not represented in the collections made by the United States Bureau of Fisheries, hence we are dependent for our description upon Seeliger's original account and Neumann's later studies of the same form.

The form of the colony is stated as variable, being usually cylindrical or conical, the open end being broader than the closed end. In young colonies with but few whorls of zoöids the closed end may be considerably the broader. The maximum length is 3 cm., the width 14 mm., although it is possible, as Seeliger thinks, that larger specimens will be found. Since no specimens over 3 cm. long have been reported (Deutsche Südpolar, and Deutsche Tiefsee-Expedition), it seems very probable that this represents about the definitive colony length for the species, especially since the zoöids in colonies of this size are sexually mature. There is a regular arrangement of the zoöids in the young colonies with 1 to 3 whorls of zoöids, but in older colonies this is completely lost. The definitive test processes in this species resemble somewhat those of *P. ovatum*, except that they are much shorter (fig. 24). In form they are thick-walled tubes, which surround the oral siphons of the zoöids and stand out perpendicular to the surface of the colony. At their ends the oral apertures are sunken in crater-like depressions and usually face directly outward, sometimes a little ventrally.

The maximum length of the zoöid is 5 mm. The oral siphon is fairly long, almost equaling the rest of the body in some cases. Its great width is significant also, the anterior wall being broad and flat. On the inner (endodermal) wall of the oral siphon pigment cells have been found, extending as far forward as the mouth (Neumann, 1913, *b*). The branchial basket is broad (dorso-ventrally), about equally so at both its ends. The endostyle is only slightly curved. There are about 24 rows of broad stigmata, and ordinarily 14 longitudinal bars. The cloaca is a little narrower than the pharynx, the cloacal muscle rather long. Pigment cells are found on the outer epithelium of the cloaca (fig. 25), as well as on the follicle wall of the testis. The testis consists of about 12 large lobes which surround the intestinal loop. The organ does not lie in an evagination of the ventral body cavity, as is ordinarily the case in other *Pyrosomas*. The ovary occupies its usual position at the right side of the testis.

Gonads. The production of germ cells commences usually before the zoöid has reached its full development, and only after the embryo is set free does the parent zoöid complete its growth. Protogyny is the rule for this species, the egg in the majority of zoöids maturing before the testis. Neumann (1913, *b*) in working over this species found that the egg tends to ripen at about the same rate in all the zoöids. This is unlike the condition in *P. verticillatum*, where the egg comes tardily to maturity in the primary ascidiozoöids and develops more and more rapidly in each succeeding whorl of zoöids, "until a certain stage is reached." In *P. aherniosum* the primary ascidiozoöids ripen their eggs first in almost every case, then the succeeding whorls of zoöids ripen theirs, in the order of their proximity to the primary zoöids; that is, in the order of their age. After the embryo is set free from the ovary it completes its brood development in the right peribranchial sac.

Seeliger finds in a large number of his specimens that there are but three primary ascidiozoöids at the closed tip of the colony, in place of the usual four, a condition arising through the atrophy of one of these four original buds. He suggests that there may be a tendency here for a distinct variety to establish itself, one characterized by the presence of only three definitive, primary ascidiozoöids. Similar freaks have often been noted in other groups of animals, as pentamerous jellyfishes.

Distribution and occurrence.—This species, although rather recently discovered, has proven to be of rather common occurrence in the Atlantic Ocean, where it was first found. It has been reported since from the Indian Ocean from six stations. Herdman (1888) has described and figured a small *Pyrosoma* from the western Pacific Ocean which he took to be the "*P. elegans*" of Lesueur. It seems more probable that he was dealing with specimens of *P. aherniosum;* this is the opinion expressed by Seeliger and by Neumann, who have worked most on this form.

PYROSOMA OVATUM (Neumann, 1909, b).

Plate 25.

This species was described from 52 specimens collected in the South Atlantic Ocean (Deutsche Süd-polar Expedition). It is specially characterized by the egg-shaped or almost spherical colony, and by the long tubelike buccal processes standing out here and there from the surface of the test. The species is quite distinct from all other known *Pyrosomas;* its characters are well defined, and there appears to be no intergrading of this with other forms. The length of the colony is given as 1 to 5½ centimeters. The processes of the test show some resemblance to those in *P. atlanticum atlanticum*, but this resemblance is probably only superficial. The surface of the colony is smooth, except for these long, slender processes. At the distal end of each process the surface of the test is raised into papilla-like elevations, or denticles, each one containing a test cell (fig. 29), and the oral aperture is surrounded by an overhanging wall of the test. In a longitudinal section (fig. 28) the test process is seen to be truncated obliquely so that the mouth opens somewhat ventrally.

A loose and irregular arrangement of zoöids obtains. Occasionally a zoöid will be found to be turned from its normal position, so that its ventral side is directed toward the aperture of the colony. The majority of individuals in the colony—that is, those lacking the oral processes—are about 5 to 7 mm. long (fig. 27). Those with the oral siphons well developed attain a maximum length of 19 mm., the siphon then measuring about 14 mm., or three-fourths of the total length of the entire zoöid (fig. 26). The inner epithelium of the oral siphon is dotted with large, star-shaped and highly branching pigment cells of a reddish color. In addition to the pigment customarily found on the follicle of the testis there are scattered pigment cells on the inner ectodermal wall of the cloaca, in the region of the viscera. The occurrence of pigment cells in the cloacal region has been observed in no other forms except *P. aherniosum* and some varieties of *P. atlanticum*, and in the latter species they are not prominent.

The branchial chamber proper is oval or oblong, higher (dorsoventrally) in front than at its posterior end. The endostyle is only slightly curved. In each branchial lamella there are 38 to 40 rows of stigmata and about 18 longitudinal bars. Dorsal languets, for the most part 9 to 10, sometimes as many as 12.

The luminous organs are small, elliptical bodies, lying equidistant from the dorsal and the ventral mid-lines of the zoöid.

The digestive tract is rather large and prominent. The esophagus has a broadly funnel-shaped aperture; it enters the triangular stomach at its posterior side. In other respects the digestive tract is as usual. The cloaca is broad, and its two lateral muscles are long.

Gonads. The testis, consisting of about 30 lobes, causes only a very slight bulge in the ventral body wall. Consequently it extends upward so as to inclose the loop of the intestine. Just to the right of the testis and a little behind it is the ovary. This species is protandrous, but the degree of protandry which obtains is not so great as in other Pyrosomas (as *P. atlanticum giganteum*). In colonies 3 or 4 centimeters long, made up of numerous zoöids, only a very few individuals can be found from which the embryos have been set free. Hence it seems probable that older colonies of this species will be found even larger than those already collected.

P. ovatum occurs in the Indian and South Atlantic Oceans.

PYROSOMA ATLANTICUM (Peron, 1804).

Plates 15, 34, and 35; plates 26–32; plate 36, figs. 50–53.

There is a large group of closely related forms which we are including in this species, classing as subspecies a number of forms previously described as species, and also several new types in our collections. To this group belong "*Pyrosoma atlanticum*" (Peron, 1804), "*P. giganteum*" (Lesueur, 1815), "*P. elegans*" (Lesueur, 1815), "*Dipleurosoma ellipticum*" (Brooks, 1906), "*P. triangulum*" (Neumann, 1909, *a*), and our new forms *hawaiiense*, *paradoxum*, and *echinatum*.

It is not possible to tell to which of our several subspecies belong the forms described by Peron and Lesueur. Those colonies of this group, collected in the Atlantic Ocean, which have been described in sufficient detail to allow exact identification, are all of the sort which we treat as the subspecies *giganteum*, and, from the large size often attained, they seem to be of the type which has long been called *P. giganteum*. The colonies which we take as the type and paratypes of the species *atlanticum* (subspecies *atlanticum*) are from the Pacific Ocean. They are distinct from the Atlantic forms generally classed as *giganteum*. They are probably the same as Huxley's southern Pacific specimens which he called *atlanticum* and are surely the same as Ritter's San Diego material named by him *giganteum*.

Somewhat intermediate between these *atlanticum* forms and the true *giganteum* are a number of colonies which we do not describe in detail, though we refer to them later under the name *intermedium*. Here would be placed the forms discussed by Seeliger and Neumann as *P. atlanticum* and its varieties *lævatum* and *tuberculosum*. Peron's *P. atlanticum* probably should be placed here. *Pyrosoma minimum* we do not discuss.

The problem of nomenclature is intricate and confused. There are no descriptions of "*atlanticum*," not even Huxley's, which are clear enough for certain identification. The earliest description of colonies in this whole *atlanticum* group, which allow fairly confident identification, apply to large Atlantic specimens and are under the name *giganteum*. Under these circumstances it might seem natural to use the name *giganteum* for the species, holding the other forms as subspecies, though this would involve redefinition of *giganteum*, but, according to taxonomic conventions, we must retain the name first applied to a member of this major species, though it is not possible to tell to which of the several subspecies the individuals first described belonged.

In 1804, Peron described the first colony of these animals discovered, giving it the name *Pyrosoma atlanticum*. From his description, and the locality of its collection, we can say only that it is a *Pyrosoma*, probably of our larger *atlanticum* group. The fuller descriptions of Lesueur (1813 and 1815) and Savigny (1816) materially advanced knowledge of the genus, and Huxley's studies (1851, 1860, *a*, 1860, *b*, and 1861) gave a still more adequate conception of its organization as well as of the reproduction. There has been much confusion between *P. atlanticum atlanticum* and the several other subspecific forms. We will make no attempt to follow through all these descriptions and resolve the confusion. The attempt would be tedious and at best only partly successful.

In our work on the extensive collections of *Pyrosoma*, made by the United States Bureau of Fisheries, we have been led to believe that no valid distinctions can be made among Atlantic forms of *Pyrosoma*, which would show the existence of the two nearly allied subspecies, *atlanticum* and *giganteum*, generally described. In the Pacific Ocean, however, there is found in comparative abundance a *Pyrosoma* which agrees with descriptions of *P. atlanticum* from the Pacific Ocean. It may occur in the Atlantic Ocean as well, but we do not find it among our 43 colonies from the Atlantic Ocean, 42 of which, collected at 30 stations, belong to the major *atlanticum* group, nor are there published descriptions which indicate the presence in the Atlantic Ocean of *P. atlanticum atlanticum*, as we define it. It seems best to recognize as *giganteum* the large colonies from the Atlantic Ocean so often described under that name.

We find, also, in the Atlantic Ocean less specialized forms of *Pyrosoma* than the typical *giganteum*, which appear to be intermediate between the Pacific type, *P. atlanticum atlanticum*, and the genuine *P. atlanticum giganteum*. These will occasionally be referred to for convenience as *P. atlanticum*, group *intermedium*, pending the study of further collections, which may indicate that some of these are distinct forms·which have not reached full development.

The major species under consideration has been most often spoken of as the typical representative of the genus. It has ordinarily been described as having a conic-cylindrical colony, beset with truncated test processes or spines; the zoöids irregularly arranged in the test, and, for the most part, long; with other general data, in no way distinctive. This brief diagnosis, while accurate enough, serves only to set off a whole group of Pyrosomas, containing many diverse varieties. These, while easy to identify if characteristic specimens are at hand, show such intergradation one with another, and conform so closely with the fundamental plan for the group, that we are treating them as varieties or subspecies of a single species which we name *P. atlanticum*. Taking up, then, the several nearly allied subspecies, we treat first the form chosen as the species type, probably the same form Huxley (1851) described as *P. atlanticum*. The selection of this form as the species type seems natural, since, during the immature stages of the growth of the colony, some of the other subspecies resemble closely the adult of the typical *P. atlanticum atlanticum*, diverging more and more from this central type as they mature.

PYROSOMA ATLANTICUM ATLANTICUM.

Plates 26 and 27; plate 28, fig. 33; plate 34, figs. 45 and 46; plate 36, fig. 53.

If we examine specimens of *P. atlanticum atlanticum*[1] from the Pacific Ocean, where the form seems to be most characteristically represented, we find remarkable variation among them in regard to size, color, and organization. The great range in size displayed here is in itself significant, when we contrast this with the species *verticillatum*, *hybridum*, *operculatum*, and *ellipticum* described previously, which are all small in comparison. The majority of specimens of *P. atlanticum atlanticum* in the *Albatross* Pacific collections do not exceed 8 cm. in length; the largest is only 12 cm. long.

Ritter (1905) has described as *P. giganteum* a type of *Pyrosoma*, found on the California coast, which agrees in almost all particulars except size with the one we here describe as *P. atlanticum atlanticum*. According to our distinction between these two forms, it would seem clear that he was dealing with material representing the latter. He was himself very uncertain about assigning his specimens to either one of the two species, as they were then treated. If his specimens were, as it seems, true *atlanticum*, it may be stated that this form is known to attain a length of 60 cm., for Ritter's largest specimen was of this size. He reports also several other exceptional specimens whose measurements are given as follows (Ritter, 1905): "Measurements of three largest preserved colonies: first, length, 25 cm., greatest thickness near open end 2.5 cm.; second, length, 25 cm., greatest thickness, 3.5 cm.; third, length, 19 cm., greatest thickness about middle of length, 3 cm.; largest colonies observed, measured in life, 60 cm. long, 40 cm. long, and 35 cm. long."

The form of the colony in the majority of specimens is conic-cylindrical, the open end of the colony being wider than the closed. There are numerous departures from this shape; some individuals are less conical, more truly cylindrical, than others; some are thickest in the middle and taper toward both ends; while in others there is the suggestion of natural flattening at the open end of the colony. That this flattening is not entirely due to artificial causes (shrinking or compression from poor preservation) is evident, for, if the diaphragm at the opening of the colony is examined, it will be found to be adapted to the form of the slit-like opening, as was shown for *P. ellipticum* (fig. 20, pl. 23). On the other hand, some quite mature colonies show no such flattening. From the data quoted above from Ritter it will be seen too that the ratio between length and thickness differs greatly with individuals. This is apparent in smaller colonies as well. For example, the dimensions of certain of our specimens are as follows: Length, 8 cm., thickness at open end, 1.8 cm., at closed end, 1.1 cm.; length, 7.5 cm., thickness at open end, 1.5 cm., at closed end, 1.2 cm.; length, 10 cm., thickness at open end, 2.3 cm., at closed end, 1.5 cm.; length, 3.1 cm., greatest thickness, at open end, 0.9 cm.; etc. As already stated, some few individuals are thickest in the middle, some are almost uniformly cylindrical, but the majority are distinctly conical, that is, they taper toward the closed end (fig. 45, pl. 34).

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[1] According to taxonomic conventions there seems no escape from the absurdity of naming these Pacific forms *atlanticum*.

The test is fairly rigid, retaining well the form of the colonial tube in preserved specimens. It is ordinarily colorless and transparent, but varies through pale yellowish to a distinct pinkish flesh-color. The color of the test may perhaps, as Herdman (1888) believes, be derived from the masses of pigment cells lying on the esophagus, intestine, and testis of the zoöid, though how they influence the color of the test is not clear. That these pigment cells may be the source of the test color is suggested by the fact that the colors of the two are about the same except for intensity, and that in the form *giganteum*, as described by Herdman, the inner zone of the test lying above these pigmented organs is deeper in shade than the outer layers. No specimens of the subspecies *atlanticum* have been reported in which there is any trace of blue or greenish color.

Characteristic of this whole group of forms is the presence of, and especially the shape of, the test processes (fig. 30, pl. 26). These are most characteristic as observed in rather young colonies (fig. 53, pl. 36). Here they arise each in connection with a zoöid. The process itself is a broad, obliquely truncated cone, the truncated surface of which faces slightly toward the closed end of the colony, i. e., in the same direction as do the ventral sides of the zoöids. Upon this truncated area the oral aperture of a zoöid is situated so that the mouth thus appears to open obliquely ventrally (fig. 30). In many younger zoöids of this type form (fig. 32) and occasionally in older zoöids of some of the other subspecies (fig. 36, pl. 29), this truncated area is depressed, forming more or less of a funnel leading to the mouth. In this particular form (*P. atlanticum atlanticum*) we have, appearing rather early, a characteristic denticulation along the lateral edges of the truncated area of the test process, and at its dorsal tip (figs. 30 and 33). This character almost serves in itself to distinguish this variety from the other varieties of the species, for it is of very constant occurrence, and, if at all well developed, seems to be one of the distinctive, though minor features indicating this race. In older colonies, test processes sometimes develop to great length, so that they give to the colony a bristling, spiny appearance (fig. 45, pl. 34). The oral processes of the corresponding zoöids lengthen themselves proportionately, so that they still continue to open near the distal ends of the test processes. As illustrating the great degree of diversity in this form, we may add here that, in one of our specimens, almost all of the oral apertures were situated near the bases of the elongated spines.

When first formed the zoöids are arranged in the test with a semblance of regularity; that is, they lie in obscurely parallel transverse rows (fig. 53, pl. 36). This appearance is undoubtedly the basis of Lesueur's distinction between his "*P. elegans*" and the other two forms then recognized (*P.* "*atlanticum*" and *P.* "*giganteum*"). More recent students believe that Lesueur was dealing with a young colony of a form which we would now class as a subspecies of the species *P. atlanticum*, probably *giganteum*,[1] for, in the young stages of this variety, the zoöids show a tendency to arrange themselves in transverse rows. With further growth and budding within the colony, (2 cm. colonies and larger) new zoöids become interspersed between the old ones; but not all of these arise as do the former, that is, each zoöid in connection with a test process. In this way, in older colonies, all appearance of regularity in arrangement is lost, and the individuals of the colony become crowded.

In size the zoöids show great diversity. Those in small colonies (2 cm.) are of about uniform dimensions and shape (fig. 32); these are from 2.5 mm. to 3 mm. in height (dorso-ventrally), from 4 mm. to 4.2 mm. long when full sized. With growth, the oral-siphons become enormously elongated in some of the older zoöids (fig. 30), and the cloacal chambers moderately so (fig. 31). The total length often amounts to as much as 8 mm. The branchial sac, or basket, maintains a more uniform size, hence may be taken as a better criterion for comparing the size of the zoöids; it is found to range from 3 mm. to 3.5 mm. in length when fully developed. Ritter, in describing his specimens, which he called *P. giganteum*, gives 3 mm. for the usual length of the branchial sac, and for the total length, including both siphons, 5 mm. to 6 mm. The thickness of the test-wall of the colony averages 4.5 mm., but may be as great as 6 mm. in large specimens. The characteristic form of the zoöid can be studied to best advantage in the small or medium-sized specimens (6 cm. or less), for, as the colonies grow larger, the individuals become highly diversified. Figure 32 shows a zoöid from a 1.5 cm. colony, in which the contour of the body is circular to oblong, the oral and cloacal chambers forming slight prominences at the ends. This same figure shows also the usual relation which the zoöid bears to the test-process. Older zoöids (fig. 30, from a 9 cm. colony) have the branchial sac more elongated so as to appear oval or oblong.

The mantle, and consequently the branchial basket, is strongly compressed in this form, perhaps owing to the crowding of the zoöids in the test.

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[1] Of this identification with *P. atlanticum giganteum* we can not be at all certain, so can not claim the relief such identification would give to the absurd nomenclature.

The musculature of the zoöids is well developed, and shows little diversity of pattern. In addition to the oral sphincter there are two distinct circum-oral fibers or rings varying in position according as the oral chamber is long or short. When this is greatly elongated they lie near its distal end, somewhat widely separated from each other. The lateral muscles of the cloaca are quite prominent. They are usually short. They lie about at the level of the digestive tract; or they may be considerably posterior to the gut when the cloaca is long, as is often the case. The cloacal sphincter is a small thick ring which maintains an almost complete closure of the cloacal opening in preserved specimens.

The mouth differs very little from that of *P. verticillatum* subspecies *cylindricum*. If anything, it is a little more constricted; while the tentacular folds are even more pronounced. These number about 18 usually, not counting the true tentacle on the ventral border.

The pre-branchial chamber is narrower than the branchial sac; it is always present as a distinct cavity or siphon. It varies greatly in length, often equaling the length of the branchial sac, or even exceeding it (4 mm. or less).

The branchial chamber proper varies from oval or quadrangular to triangulate, narrowing toward the posterior end. Many times it will be found to be even harp-shaped owing to the strong curvature of the endostyle at its anterior end.

In each wall of the branchial basket there are 14 to 15, occasionally 16, longitudinal bars; 30 to 36 stigmatal rows. Dorsal languets, from 6 to 10 in mature zoöids; in small colonies (1.5 cm.) the normal number is 4 to 5.

The dorsal masses of leucocytes form organs which are more prominent than usual, but they are not so distinctly separated.

The ganglion is small, or of moderate size. In number and arrangement, the nerves are as is typical for this subgenus (fig. 13, pl. 22). Two pairs extend forward from the ganglion, four out to the sides, and two backward. The third and fourth pairs of nerves are sometimes difficult to identify, because the third often tends to fuse for a distance with the second, and the fourth nerve is never very distinct at best.

The luminous bodies are comparatively large; in form they are oval or oblong, or sometimes circular as seen in side view.

Digestive tract. In this, as in the subsequent varieties of this species, the stomach is larger and more spherical in appearance than we have found it to be in the species we have thus far described; while the intestine is thick, and forms a round rather than a sharply bent loop. There have been demonstrated, for these forms also, definite masses of reddish pigment cells lying on the esophagus and on the intestine, and occasionally some on the surface of the testis. These latter are very much in evidence in the yellowish colonies of *P. atlanticum giganteum*, where they can sometimes be seen with the unaided eye. It is this pigment which is thought to give the sand-yellow color to so many *Pyrosoma* colonies. The specimens of all forms of the species *atlanticum* collected by the *Albatross* in the Pacific are for the most part colorless or white.

The cloacal chamber is quite variable in form and size. It rarely exceeds half the length of the branchial sac; as typically developed it is much shorter than this. Its aperture is small. In good sized colonies young zoöids, that is, independent buds, have long, neck-like oral and atrial siphons which seem to shorten somewhat (relatively) as these zoöids mature. When the cloaca is long it is usually narrow, and its pair of muscles correspondingly short; when short it may be quite broad.

Gonads. The testis is a fairly compact, spherical body, consisting of 12 to 15 lobes. It protrudes strongly beyond the ventral body contour. Many of the well formed zoöids of the colony are protandrous. According to our observations, in the majority of buds the egg ripens first, while in others the two come to maturity at about the same time. In other words, there is a strong tendency for a protandrous relation to establish itself in many individuals in the colony, probably, as Neumann thinks, as a result of the rapid rate at which budding occurs. This formation of buds by the early formed zoöids, increasing the size of the colony, diverts nutriment from the growing germ cells, and the egg, which requires abundant nutrition for its growth, has its development retarded. The testis is thus enabled through its slow but steady growth to reach maturity first. The egg when fully grown is larger than the testis by one or two diameters. When it finally becomes detached from its position in the ovary, it completes its brood development in the cloaca of the zoöid—not in one of the peribranchial pouches.

P. atlanticum atlanticum is one of the most abundant forms of *Pyrosoma* known. It is certainly the predominant form in the Pacific Ocean, where it is of common occurrence on both the east and west sides (California coast, vicinity of Philippine Islands, and the coast of Japan), and the Pacific Ocean is probably more prolific in *Pyrosomas* than is any other one of the great oceans. The largest number of species is reported from the Indian Ocean, but in number of colonies the collections from the Pacific probably surpass even those from the Indian Ocean. Its occurrence in the Atlantic Ocean as a form well demarcated from *giganteum* is a little doubtful. We find numerous specimens in the Atlantic Ocean, showing various intermediate conditions, but none which could be considered characteristic *atlanticum atlanticum.* It is more likely that they are, in part, divergent individuals—in some cases immature specimens—of *giganteum*, and perhaps, to some extent, intermediate forms resulting from the intercrossing of *giganteum* with individuals of *atlanticum atlanticum* which had migrated from the Pacific. *Atlanticum atlanticum* is also reported as occurring in the Indian Ocean. Among the forms reported from the Atlantic Ocean, Seeliger's *P. atlanticum tuberculosum* approaches most nearly the specimens from the Pacific Ocean, which we here describe as *P. atlanticum atlanticum.* It seems absurd to apply the name *atlanticum* to forms known chiefly, and possibly only, from the Pacific Ocean, though others, especially Huxley (1851), have so named them. We therefore must ignore the absurdity of the name.

Specimens of *P. atlanticum atlanticum* were obtained during the cruise of the *Albatross*, as indicated below:

Albatross Philippine Expedition, 1907–1910:

D. 5120, Sombrero Island, Verde Island Passage; January 20, 1908; 393 fathoms; surface temperature, 43.7° F.; surface density, 1.02386; 13 specimens, Cat. No. 6449 U.S.N.M.

D. 5125, Nogas Island, Sulu Sea, vicinity southern Panay; February 3, 1908; 411 fathoms; surface temperature, 80° F.; surface density, 1.02444; three specimens, Cat. No. 6505, U.S.N.M.

D. 5128, Nogas Island, Sulu Sea, vicinity southern Panay; February 4, 1908; surface; surface temperature, 80° F.; 13 specimens, Cat. No. 6439, U.S.N.M.

D. 5155, Bakun Point, Tawi Tawi Group, Sulu Archipelago; February 19, 1908; 12 fathoms; surface temperature, 81° F.; surface density, 1.02437; one specimen, Cat. No. 6506, U.S.N.M.

D. 5175, Manucan Island, Sulu Sea, southeast of Cagayanes Islands; March 8, 1908; surface; surface temperature, 82° F.; four specimens, Cat. No. 6403, U.S.N.M.

D. 5183, Lusaran Light, between Panay and Negros; March 30, 1908; 96 fathoms; surface temperature, 81° F.; surface density, 1.02489; one specimen, Cat. No. 6501, U.S.N.M.

D. 5195, Capitancillo Island Light, off northern Cebu Island; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; one specimen, Cat. No. 6502, U.S.N.M.

D. 5223, Malabrigo Light, between Marinduque and Luzon; April 24, 1908; surface; surface temperature, 84° F.; one specimen, Cat. No. 6509, U.S.N.M.

D. 5263, Point Origon, off eastern Mindoro; June 4, 1908; 65 fathoms; surface temperature, 83° F.; one specimen, Cat. No. 6490, U.S.N.M.

D. 5299, China Sea, vicinity of southern Luzon; August 8, 1908; 524 fathoms; surface temperature, 83° F.; surface density, 1.02396; one specimen, Cat. No. 6507, U.S.N.M.

D. 5331, Hermana Menor Island, off western Luzon; Nov. 22, 1908; 178 fathoms; surface temperature 80° F.; surface density 1.02422; Cat. No. 6491 U.S.N.M.

D. 5366, Escarco Light, Batangas Bay, Luzon; Feb. 22, 1909; 240 fathoms, surface temperature 79° F.; one specimen, Cat. No. 6508 U.S.N.M.

D. 5409, Capitancillo Island Light, off northern Cebu Island; March 18, 1909; 189 fathoms; surface temperature 80° F.; five specimens, Cat. No. 6419 U.S.N.M.

D. 5410, Bagacay Point Light, between Cebu and Leyte; March 18, 1909; 385 fathoms; surface temperature 80° F.; three specimens, Cat. No. 6404 U.S.N.M.

D. 5437, Hermana Mayor Light, west coast of Luzon; May 8, 1909; 100–600 fathoms; surface temperature 86° F.; twelve specimens, Cat. No. 6494 U.S.N.M.

D. 5613, Buka Buka Island, Gulf of Tomini, Celebes; Nov. 20, 1909; 752 fathoms; surface temperature 84° F.; one specimen, Cat. No. 6504 U.S.N.M.

D. 5331, Hermana Menor Island, off western Luzon, Philippine Islands; Nov. 22, 1908; surface; surface temperature 80° F.; surface density 1.02422; three specimens, Cat. No. 6491, U.S.N.M. These specimens we have not studied.

Jolo anchorage, Electric Light, March 5, 1908; one specimen, Cat. No. 6503, U.S.N.M.

Albatross Northwestern Pacific Cruise 1906:

D. 5064, off Ose Saki, Suruga Gulf, Japan; Oct. 15, 1906; 575 fathoms; surface temperature 69° F.; twelve specimens, Cat. No. 6492 U.S.N.M.

Other specimens in the collection of the United States National Museum are as follows: Carnegie Magnetic Expedition between Hawaii and California (not more accurately located); one specimen, Cat. No. 6500 U.S.N.M.

Three specimens from an unnumbered station off La Jolla, California, July 23, 1904 (Ritter), two of these are Cat. No. 6485 U.S.N.M.

One specimen, from Ward's Natural Science Establishment, from the "South Pacific," Cat. No. 6511 U.S.N.M.

Two small specimens of doubtful identification taken by the *Albatross* at:

D. 3750, off Honshu Island, Japan; May 10, 1900; 83–140 fathoms; surface temperature 65° F.; one specimen.

D. 5124, Point Origon, off eastern Mindoro; Feb. 2, 1908; 281 fathoms; surface temperature 79° F.; surface density, 1.02468; one specimen, dried out.

One hybrid (?) and another specimen of doubtful subspecific rank were taken in the Philippines, as follows:

PYROSOMA ATLANTICUM ATLANTICUM × P. ATLANTICUM DIPLEUROSOMA.

Cat. No. 6471, U.S.N.M., (Type) *Albatross* station D. 5223, Malabrigo Light, between Marinduque and Luzon, April 24, 1908; surface; surface temperature 84° F.; one specimen.

PYROSOMA ATLANTICUM, subspecies.

Cat. No. 6625, U.S.N.M., *Albatross* station D. 5124, east coast of Mindoro, Philippine Islands; Feb. 2, 1908; surface; surface temperature, 79° F.; surface density, 1.02468; one specimen.

PYROSOMA ATLANTICUM HAWAIIENSE, new subspecies.

Plate 28, fig. 34; plate 35, fig. 49.

This is a form occurring in the northern Pacific Ocean, which, according to our present knowledge, is truly distinct. All of the specimens (six) were collected at one "catch," from a depth of five fathoms, at a station between the Hawaiian Islands and California. The characters by which this form is known make it so unique that it might well be considered a new species, but its relation to the species *atlanticum* is so evident that it seems well to class it as a subspecies of *atlanticum*. In dealing with these spinous forms the safer course has seemed to be to treat them all as nearly related, although perhaps distinct, subspecies, because of the manifest tendency on the part of some to intergrade with others.

The colony is long and quite cylindrical, tapering scarcely at all toward the closed end; some specimens are a little fusiform. The cormus is relatively more slender than in specimens of *P. atlanticum*. For example, the dimensions of the six specimens studied are as follows: length of first 11 cm., width (average) 1.7 cm.; second, length 12 cm., width 1.4 cm. (1.6 cm. at open end, 1.2 cm. at closed end); third, length 16 cm., width 2 cm.; fourth, length 16 cm., width 2.2 cm.; fifth, length 16 cm., width 2.4 cm.; sixth, length 17 cm., width 2.4 cm. From these figures it will be seen that there is remarkable uniformity in the size and the form of the colonies, with only slight differences in the relative width of each.

The test processes are low, rounded protuberances with extremely blunt ends. Over the entire outer surface of the colony there are minute rounded elevations, which are visible only under magnification, these giving to the test a granular opaqueness. It is worth remarking here that the test processes of the largest colonies are all proportionately more reduced in height and broader than those of the smaller colonies, a condition which would suggest that the ancestral form from which this variety was derived had longer and more pointed test processes. This is just what we should expect if the form we are describing is a subspecies of *P. atlanticum*. The test walls of the colony are thick (about 6 mm.) and very rigid even in formalin specimens. The colonial aperture is a very small, round pore.

There are some points of taxonomic interest in connection with the zoöids. Of these structural modifications there should be mentioned the shortening of the oral or prebranchial chamber—except in those zoöids which open onto test processes; the displacement of the cloaca dorsally; a peculiar disposition of the digestive organs, giving a spheroidal appearance to the stomach, and a rotation of the esophagus so that it opens almost from the dorsal side of the pharynx. There are about 30 to 32 stigmatal rows, and 15 to 16 (occasionally 17) longitudinal bars in each of the branchial lamellae. The number of dorsal languets is pretty constantly 8 to 9. The length of the zoöid varies with the colony from 4.5 mm. to 6 mm., the height from 2 mm. to 3 mm. (averaging 2.3 mm.). The cloaca is usually three-fourths as long as the branchial sac, but it may be much shorter than this, especially if the colony is small. It is rather uniformly 2 mm. to 2.4 mm., long in zooids from the larger colonies. The cloacal muscle lies at about its middle.

In this form the gonads are quite prominent, hence easy to observe. The ovary is a large hemispherical compartment, which, when full-sized, bulges out beyond the ventral contour of the body. In its cavity the single, large egg develops until it is set free by the rupturing of the inner cloacal epithelium. The embryo, thus loosed, continues its metamorphosis for a time in the cloaca of the zoöid. There are about 14–17 lobes in the testis, which hold together as a fairly compact or rounded-hemispherical body. If a study is made of a small colony (the smallest one referred to above was used) it will be found that practically all the zoöids are protandrous; but in the largest colonies the reverse condition obtains; that is, with hardly an exception in the developing zoöids, the egg comes to maturity much before the testis has reached its definitive size (fig. 34). This seems to be in keeping with Neumann's hypothesis that it is the rapid budding within the colony which delays the development of the egg and results in a condition of protandry. In this particular variety, it is probable that the colony reaches a definitive size which corresponds roughly to that of our largest specimens, and probably in consequence of this, the rate of budding is somewhat slackened in older specimens and the primitive condition of protogyny is allowed to establish itself.

Distribution. As mentioned at the head of this description, only six specimens of this form are known. These were all collected in the north Pacific Ocean, somewhere between the Hawaiian Islands and California. Carnegie Magnetic Expedition, between Hawaii and California, not more accurately located; six specimens, Cat. Nos. 6443 (Holotype) and 3069 (Paratypes) U.S.N.M.) It seems likely that this is a geographical subspecies, whose distribution is limited to the waters of the Pacific.

PYROSOMA ATLANTICUM PARADOXUM, new subspecies.

Plate 29, figure 35.

Among the specimens of *Pyrosoma* collected in the Pacific by the *Albatross*, was one which in general appearance closely resembled *P. atlanticum atlanticum*. On making a study of the zoöids, however, certain small but distinctive differences were found. In making this a subspecies, then, we describe conditions as they are found, not for the purpose of multiplying varieties indefinitely, but rather to point out and illustrate the great degree of divergence in this group.

As characteristic of the colony, should be mentioned its remarkable limp and gelatinous condition (formalin preservation), which is exceptional in this major species; also the weak development of the colonial diaphragm, and the consequent large size and irregular contour of its aperture. The test-vessels running into the diaphragm appear to have degenerated completely. In other respects the colony resembles that of *P. atlanticum atlanticum:* the test is very transparent, the zoöids whitish; test-processes fairly long and tapering, with oblique areas of truncation which are a little denticulate on their edges. The dimensions of the colony are, length 8.6 cm., width, at open end 2.4 cm., at closed end 1.3 cm.; from which it will be seen that the colony tapers rather strongly. There is a suggestion of flattening, but this may not be natural. The zoöids are irregularly arranged in the test.

But the features which most strongly characterize this subspecies are found in the zoöid. The mantle, and in fact all the tissues of the body, are quite delicate. The branchial components are more numerous than in the subspecies *atlanticum*: of longitudinal branchial bars there are 16-17, only rarely 15: the rows of stigmata are 33-37. There are about 9 dorsal languets. Other differences more difficult to describe may be noticed on contrasting this with its related forms. The luminous organs have a compact epithelium-like structure, because the cells of which they consist are polyhedral and fit together closely, whereas these cells are separated or even scattered in other *Pyrosomas*. The stomach wall has a similar thin, epithelial texture. In addition, the shape of the stomach is somewhat peculiar, being cylindrical, long, and with squarish ends. The branchial sac presents a characteristic oval contour as seen in side view, its ventral wall bulging strongly so as to give to the endostyle a strong even curvature. This latter organ, it should be noted, is shorter than the branchial region proper, a feature not found in other forms of the species *P. atlanticum*. The dorsal masses of leucocytes are reduced to small size. Dimensions of the zoöids: average length 4.6 mm. (4.2 mm.–5 mm.); average height 2.5 mm. (2.2 mm.–2.8 mm.). The oral and cloacal chambers are both short. Cloacal muscles rather narrow and short.

Gonads. The testis is a compact body, consisting of about 14 lobes. In form it is narrowly hemispherical to globose. It was relatively small in the specimen studied, which was perhaps not mature. In the colony, no eggs were found which had progressed beyond the one-cell stage. Since these were all very small and the testes relatively large, it seems that the zoöids are protandrous. On dissection, mature spermatozoa were found in the testis of one individual. The ovum in this same zoöid was nearly mature, but did not appear to have been fertilized. In the flasklike receptacle connected with it sperms were found (fig. 5, p. 208).

Occurrence and distribution. The only known specimen of this form was found in the Pacific Ocean, being collected northwest of the Hawaiian Islands, during the *Albatross* Philippine Expedition, 1907–1910: latitude 25° 10′ N.; longitude 166° 20′ W., Nov. 3, 1907; one specimen, Cat. No. 6409 (Type) U.S.N.M.

PYROSOMA ATLANTICUM, form DIPLEUROSOMA Brooks, 1906.

Plate 32, figs. 39–41; plate 34, fig. 47.

This *Pyrosoma*, which we here treat as a form of *P. atlanticum*, has already been described by Brooks under the generic name *Dipleurosoma*. That it is not so distinct as to be made the type of a separate genus is very evident to one who has had the privilege of observing large collections. In fact, except for the one feature so prominent, namely the flattening of the colony, it would be rather impracticable to draw any lines of distinction between this form and the typical *P. atlanticum atlanticum*, which also sometimes shows more or less flattening of its colonies, especially near the open end. It may well be that we do not have a distinct race represented here, but merely an interesting phase, exhibiting itself in various individuals of the *P. atlanticum* group, both in the Atlantic and in the Pacific Oceans. This is further indicated by the fact that there are many intergrading forms which are flattened only slightly (see description of *P. atlanticum atlanticum*). The form *dipleurosoma* appears to be not uncommon.

The characteristic shape of the colony is represented in figures 39 to 41, which are copied from Brooks's drawings of a *Dipleurosoma* taken in the Gulf Stream. We have material from the vicinity of the Philippine Islands in which the form of the colony corresponds almost exactly with that shown in the above figures. The test wall forms a permanently flattened tube, and, as was shown for *P. ellip-*

ticum (fig. 20, pl. 23), this flattening must be natural, and not the result of mechanical pressure, for the diaphragm is so formed at the ends of the elliptical aperture that any attempt to bring the colony to a cylindrical form would rupture the diaphragm at these points. The proportions of different colonies are various. They are as follows for several of our specimens: length, 12 cm., width, 2.8 cm.; length, 12 cm., width at open end, 4 cm., at closed end, 2.5 cm.; length, 12.4 cm., width at open end, 3.5 cm., at closed end, 2.5 cm.; length, 9.8 cm., width, 3.2 cm.; length, 4.3 cm., width, 1.4 cm., etc. That is, some colonies are relatively broader than others; some taper strongly, others scarcely at all. The larger of these colonies measure from 7 mm. to 10mm. in thickness. The test is either transparent and colorless or more often it is somewhat flesh-colored or yellowish. The test processes also show various degrees of development. They may be quite absent —except for a few slight elevations—or they may be large and numerous. The processes are rarely long or tapering, but almost all show the characteristic truncation at their ends.

The zoöids do not differ in essentials from those of the subspecies *atlanticum*. They vary greatly in shape and in size: length of average individuals about 4 mm.; height, from 1.2 mm. to 2.2 mm. The oral processes are for the most part relatively short; the cloacal cavities longer, but rarely exceeding the length of the pharanx. Owing to the subsequent crowding of the buds in the older colonies, the resulting zoöids tend to become narrow and often quadrangular. In the majority of the zoöids the egg appears to mature after the testis has developed. Hence we probably have here a strong tendency toward protandry within those zoöids which are rapidly budding, as already mentioned in connection with preceding forms.

Our knowledge of the distribution of the form *dipleurosoma* is probably quite incomplete. It was first found in the Gulf Stream off the coast of North Carolina. We have 14 specimens from the vicinity of the Philippine Islands, North Pacific Ocean, and one from the South Pacific Ocean, as follows:

Albatross Philippine Expedition, 1907–1910:

D. 5196, Capitancillo Island Light, off northern Cebu Island; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; two specimens, Cat. Nos. 6469 (Holotype) and 6420 (Paratype), U.S.N.M.

D. 5262, Point Origon, off eastern Mindoro; June 4, 1908; surface; surface temperature, 83° F.; surface density, 1.02448; three specimens, Cat. No. 6411, U.S.N.M.

D. 5398, Gigantangan Island, between Masbate and Leyte; March 15, 1909; 114 fathoms; surface temperature, 80° F.; two specimens, Cat. No. 6483, U.S.N.M.

D. 5403, Capitancillo Island Light, off northern Cebu Island; March 16, 1909; 182 fathoms; surface temperature, 81° F.; two specimens, Cat. No. 6410, U.S.N.M.

D. 5408, Capitancillo Island Light, off northern Cebu Island; March 18, 1908; 159 fathoms; surface temperature, 80° F.; surface density, 1.02462; five specimens, Cat. No. 6440, U.S.N.M.

One specimen, from Ward's Natural Science Establishment, from the "South Pacific," Cat. No. 3182, U.S.N.M.

Six specimens from the Southern Californian coast, 1 mile south of Catalina Island, U.S.N.M., "acc. 397, T. 127. 3–30–16."

One hybrid of *Pyrosoma atlanticum dipleurosoma* × *P. atlanticum paradoxum*.

D. 5196, Capitancillo Island, off northern Cebu Island, Philippine Islands; April 3, 1908; surface; surface temperature, 82° F.; surface density, 1.02518; one specimen, Cat. No. 6420, U.S.N.M.

PYROSOMA ATLANTICUM, subspecies GIGANTEUM (P. GIGANTEUM, Lesueur, 1815).

Plate 30, fig. 37.

This is the best-known form of *Pyrosoma*, as it was one of the first to be described and occurs in relative abundance in the North Atlantic Ocean. But in the several attempts to work out its distribution there has been great confusion and misunderstanding. As *P. atlanticum giganteum* we recognize a form which reaches its typical development in the Atlantic Ocean—a Pyrosoma which ordinarily attains a large size and is recognized by certain characteristics which, if taken together, make it rather distinct. It seems to intercross, however, with other less specialized races of the major species *atlanticum*, so that its identification is not at all certain unless typical specimens are at hand. Consequently, if we are to continue the use of this name *giganteum* it ought to designate a particular, well-defined subspecies or variety. The application of this name to all Pyrosomas of large size leads to misunderstanding as to the identity of the one in question; for size alone, unless shown through extensive collections to be distinctive, is at best a poor criterion by which to identify a Pyrosoma.

We have 16 *Pyrosoma* colonies, from 15 different stations in the Atlantic Ocean, which truly correspond to the published descriptions of "*P. giganteum*." Fully 13 other Pyrosomas were collected in the same waters, from 11 stations, which might very well be referred to the same subspecies. We have chosen, however, to treat these latter apart from the more typical 16, not because we believe they are a distinct race, but in order to avoid confusion in describing the subspecific character. As mentioned above in connection with *P. atlanticum atlanticum*, it is possible that these various aberrant specimens found in the Atlantic result from the intercrossing, perhaps some generations ago, of individuals of the two nearly allied races, *giganteum* and *atlanticum*.

[We have adopted the term "group *intermedium*" as a convenience to include all these doubtful forms. It is not at all a distinct subspecies and needs no extended description. Our specimens are very diverse in form and in color. Some colonies are long, slender, and cylindrical, others short and thick. For the most part the elevations on the surface of the test suggest papillae rather than processes or spines. The outer surface of the colony is often finely denticulate or wrinkled, a thing rather characteristic of most Atlantic forms. The test is usually yellowish or pinkish flesh-color. One colony contains zoöids which are quadrangular in side view and have the dorsal leucocyte masses thick, broad, and merged together along the mid-dorsal line. Other specimens resemble typical *atlanticum atlanticum* in the character of their zoöids. So that at best we can say only that there is great diversity within the group. Specimens representing this "*intermedium*" group were obtained by the *Albatross* off the east coast of North America at the following stations:

D. 2039, off Maryland; July 28, 1883; 2369 fathoms; surface temperature 81° F.; one specimen, Cat. No. 6497, U.S.N.M.

D. 2058, off Nantucket; Aug. 30, 1883; 35 fathoms; surface temperature 58° F.; two specimens.

D. 2092, south of Block Island; Sept. 21, 1883; 197 fathoms; surface temperature 67.5° F.; one specimen.

D. 2396, off Cape San Blas, Fla. Gulf of Mexico; Mar. 13, 1885; 335 fathoms; surface temperature 66° F.; one specimen, Cat. No. 440, U.S.N.M.

D. 2602, off Cape Lookout; Oct. 18, 1885; 124 fathoms, surface temperature 78°; one specimen, Cat. No. 2729, U.S.N.M.

D. 2626, off Charleston, S. C.; Oct. 21, 1885; 353 fathoms; surface temperature 76° F.; two specimens, Cat. No. 2737, U.S.N.M.

D. 2667, off Fernandina, Fla.; May 5, 1886; 273 fathoms; surface temperature 75° F.; one specimen, Cat. No. 794, U.S.N.M.

D. 2669, off Fernandina, Fla.; May 5, 1886; 352 fathoms; surface temperature 77° F.; one specimen, Cat. No. 797, U.S.N.M.

D. 2673, off Charleston, S. C.; May 6, 1886; 240 fathoms; surface temperature 77° F.; one specimen, Cat. No. 804, U.S.N.M.

D. 2675, off Charleston, S. C.; May 6, 1886; 327 fathoms; surface temperature 75° F.; one specimen, Cat. No. 6496, U.S.N.M.

An unnumbered station "off Pensacola," Fla.; one specimen, Cat. No. 2761, U.S.N.M.]

Colony. *P. atlanticum giganteum* is of increased interest because it has been extensively studied by European workers. The colony undergoes considerable change in passing from the young condition to extreme development. Small colonies are conic-cylindrical, semitransparent, and are not deeply colored. The test processes then show the characteristic oblique truncation at their ends. These soon lose their typical form, becoming long and irregular in shape, or reduced in size and nodular. Among our largest specimens we find exhibited all those color phases described by Savigny (1816, *b*) for *P. giganteum*, as then named. Some are strongly bluish, but not diaphanous as Savigny has described his. (This opacity may result only from preservation.) Some are greenish; the majority, however, are brownish or tan-yellow. But we fail to find the same correlation between the color of the colony and the shape of the test processes, which Savigny reports. The test processes for the most part, even in specimens differing greatly in color, are thick, rounded papillae, while, scattered here and there, are long, fingerlike tentacles. An occasional specimen is completely covered with these longer processes, which are sharply pointed and flattened at their tips as a result of the extremely oblique truncation. The surface of the colony usually presents a finely denticulate or wrinkled appearance under magnification. The test wall, as seen in preserved specimens, is rigid and cartilaginous. Its average thickness is about 7.5 mm. (from 6 to 8 mm.), varying of course with different colonies. A diaphragm is always present, although sometimes reduced. It is relatively narrow in large colonies, where its width equals one-third to one-half the radius of a section through this end of the colony. Hence the aperture is relatively large.

The dimensions of certain of our specimens are as follows: first, length 19.5 cm., width at open end 3.6 cm., at middle 3.9 cm., at closed end 2.5 cm.; second, length 31 cm., width at open end 4 cm., at middle 4 cm., at closed end 2.6 cm.; third, length 40 cm., width at open end 3.5 cm., at closed end 1.6 cm. The colony does not taper greatly, and may well be said to be more cylindrical than *P. atlanticum atlanticum*, but this one feature has little taxonomic value. Herdman (1888) gives the dimensions of a specimen captured south of Australia, which is probably of this subspecies, to judge from the description appended. They are as follows: length 36 cm., breadth at open end 3 cm., at widest point 4.5 cm., at closed end 1.5 cm.; the diameter of the common cloacal aperture 1 cm.; thickness of the test 0.4 cm. He reports also a fragment from a colony which is 7 cm. in breadth, with an aperture 4.5 cm. in diameter. The total length of such a specimen would probably exceed 55 cm., to judge from calculations based on the relative dimensions given above.

An irregular arrangement of the zoöids establishes itself very early. These then become crowded and as a result assume various abnormal positions in the test. Sometimes a group of them are inclined or bent over *en masse*; or individuals may become completely reversed, that is, may be with their ventral side directed toward the aperture of the colony, but this is rather unusual. For the most part the zoöids are long and slender, owing to the extreme elongation of the cloacal processes. The total length, corresponding roughly to the thickness of the test, approximates 7.4 mm. (large colonies). The height of the zoöids is 2.4 mm. to 3 mm. The cloaca is ordinarily 3 mm. long, ranging between 2.6 mm. and 3.6 mm. The elongated branchial basket is best defined as oblong. At the anterior end the tip of the endostyle causes an elbowlike protrusion in the body wall, best understood by reference to the figure. In each branchial lamella there are about 36 stigmatal rows, and 17–18 longitudinal bars (occasionally only 16, or as many 20).

These numerical distinctions, according to our experience, serve better than any others in demarcating this form from *P. atlanticum atlanticum* for in none of the Pacific specimens of *P. atlanticum* which we have examined could we find more than 16 longitudinal bars in each gill-lamella. Ritter found 15 to be the maximum number of these branchial bars, in the specimens which he describes as *P. giganteum*, but which we have regarded as of the subspecies *atlanticum*. In the Atlantic Ocean, however, there is a rather similar form, our *giganteum*, with nearly cylindrical colony, of yellow or bluish color, with greatly elongated zoöids, and whose branchial bars usually number 17 or 18, sometimes as many as 20. Here seems to be the clearest distinction between these two forms so long confused.

As before noted, there are often masses of reddish pigment lying on the viscera. These have been found on the esophagus and the intestine, and in some cases on the testis. Often they are so distinct as to be readily seen without a lens, after the wall of the colony has been cut. We do not find these pigment masses in the zoöids of any but the yellowish colonies. In the blue ones the viscera are densely opaque, and of dull bluish or gray color. The red pigment may have something to do with the yellow color of the test, but it is hard to see how any such connection could exist. The color of the test, at least in some of the greenish colonies, is most dense in the outer, peripheral zone.[1] In this region also the test-cells are most numerous, which may indicate that these cells have something to do with the color of the test.

Rather characteristic of this form, is the great length of the cloaca. It tapers regularly toward its distal end. The cloacal muscle occupies a position about midway of its length.

Gonads. This is another of those forms in which protandry is common among the zoöids of growing colonies. The testis is a large hemispherical organ consisting of a variable number of lobes (18 in one instance). The embryo finishes its brood-development in the cloaca of the parent zoöid.

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[1] *See* Herdman (1888, p. 28) to the contrary.

Occurrence and distribution. This is the commonest Pyrosoma in the Atlantic Ocean. It seems to be the only one thus far reported from the Mediterranean Sea. The *Challenger* took specimens in the Antarctic Ocean, south of Australia, in latitude 47° 25′ S. From the Antartic Ocean it would be easy for this form to be carried into the Indian and Pacific Oceans. In the Indian Ocean its occurrence has been pretty well established, but reports of *P. atlanticum giganteum* occurring in the Pacific are not so clear. The published descriptions of Pacific forms which could be classed in the *atlanticum* group apply only to what we have been calling the subspecies *atlanticum.*

Specimens of *P. atlanticum giganteum* in the United States National Museum collection are as follows:

Taken by the *Albatross* on the east coast of North America at station—

D. 2088, south of Marthas Vineyard, Sept. 20, 1883; 143 fathoms; surface temperature 68° F.; one specimen, Cat. No. 200 U.S.N.M.

D. 2089, south of Marthas Vineyard; Sept. 20, 1883; 168 fathoms; surface temperature 69° F.; one specimen, Cat. No. 6402 U.S.N.M.

D. 2091, south of Block Island; Sept. 21, 1883; 117 fathoms; surface temperature, 69 ° F.; one specimen, Cat. No. 6487 U.S.N.M.

D. 2094, south of Block Island; Sept. 21, 1883; 1,022 fathoms; surface temperature 68° F.; one specimen.

D. 2171, off Maryland, July 20, 1884; 444 fathoms; surface temperature 75° F.; one specimen.

D. 2381, off New Orleans, Gulf of Mexico; March 2, 1885; 1,330 fathoms; surface temperature 69° F.; one specimen, Cat. No. 428, U.S.N.M.

D. 2642, Straits of Florida; April 9, 1886; 217 fathoms; surface temperature 74° F.; two specimens, Cat. No. 790, U.S.N.M.

D. 2655, north of Great Bahama Island; May 2, 1886; 338 fathoms; surface temperature 76° F.; one specimen, Cat. No. 791 U.S.N.M.

D. 2668, off Fernandina, Florida; May 5, 1886; 294 fathoms; surface temperature 76° F.; one specimen, Cat. No. 792, U.S.N.M.

D. 2674, off Charleston, South Carolina; May 6, 1886; 316 fathoms; surface temperature 76° F.; one specimen, Cat. No. 799 U.S.N.M.

D. 2714, off Cape Henry; Sept. 17, 1886; 1,825 fathoms; one specimen, Cat. No. 874 U.S.N.M.

An unnumbered station south of Block Island (240 miles east of Cape Cod); one specimen, Cat. No. 6405, U.S.N.M.

Taken by the *Fish Hawk*, while dredging in Gulf Stream, during the year 1903:

Sta. 7518, off Cape Florida; March 30, 1903; 156 fathoms; surface density 1.024; one specimen, Cat. No. 6510, U.S.N.M.

Sta. 7519, off Cape Florida; March 30, 1903; 186 fathoms; surface density, 1.024; one specimen, Cat No. 6498 U.S.N.M.

PYROSOMA ATLANTICUM, subspecies TRIANGULUM.

(P. TRIANGULUM, Neumann, 1909, a).

Plate 29, fig. 36.

This form was first discovered in the Indian Ocean (Deutsche Tiefsee Expedition). From the careful description given by Neumann of the single specimen captured, there can be no doubt as to its relationships. During the *Albatross* Philippine Expedition two *Pyrosoma* colonies were collected, which agree in about all particulars with Neumann's *P. triangulum;* that is, the colony is conic-cylindrical, yellowish, and resembles closely the smaller specimens of *giganteum*. The zoöids have somewhat triangular pharyngeal chambers, and are further characterized by a short, broad cloaca, a small number of branchial bars and stigmatal rows, and by certain other minor features.

Among Pacific specimens of the species *atlanticum* we find so many which approach this one in the triangular character of the branchial basket that we deem it unwise to treat this as other than a subspecies.

Our two colonies of this subspecies, one 8 cm., the other 9 cm. long, differ from other *Pyrosomas* collected near the Philippines in being more deeply colored (yellowish). They show greater affinity with Atlantic forms in this respect, and also in the fact that the test processes are weakly developed, short, and for the most part sharply tipped.

The zoöids are irregularly arranged and closely placed. They attain a length of 6 mm. (Neumann); in our specimen they are smaller, from 4 mm. to 5 mm., or averaging 4.5 mm. long; average height about 2.3 mm. As characterizing the subspecies, their blunt, triangular form is noteworthy. This is due to the extreme shortness of the branchial basket, relative to its height, and to the sharp bend which the endostyle makes near its anterior end. This effect is increased because the cloaca, and the viscera lying anterior to it (the gut and testis), are displaced somewhat toward the dorsal side of the animal. In each branchial lamella the number of longitudinal bars is pretty constantly 13–14, of stigmatal rows 25–27. There are from 6 to 8 dorsal languets. The cloaca is rather broad, the cloacal muscle long. The testis, consisting of about 15 lobes, shows no unusual conditions.

One of our specimens presents a characteristic condition of progression in the manner in which the sex cells mature in different parts of the colony. At the middle, and near the closed end of the colony, the majority of the zoöids are protandrous; around the open end of the colony practically all are protogynous. So we have here another of those forms which are referred to as protandrous—meaning, of course, that there is a preponderance of protandrous zoöids within the growing colony.

Distribution: *P. atlanticum triangulum* occurs in the Indian and Pacific Oceans. In the Indian Ocean one specimen was taken by the *Valdivia* in 1899 off the Somali coast (Deutsche Tiefsee Expedition station 263). The following specimens were taken by the *Albatross* during the Philippine Expedition of 1907–1910, and off Japan in 1910:

D. 5402, Capitancillo Island Light, off Northern Cebu Island; March 16, 1909; 188 fathoms; surface temperature, 81° F.; one specimen; Cat. No. 6495, U.S.N.M.

D. 5410, Bagacay Point Light, between Cebu and Leyte; March 18, 1909; 385 fathoms; surface temperature, 80° F.; one specimen; Cat. No. 6415, U.S.N.M.

An unnumbered station off Honshu, Japan, 1910, one specimen.

PYROSOMA ATLANTICUM ECHINATUM, new subspecies.

Plate 35, fig. 48; plate 31, fig. 38.

A single, large *Pyrosoma* specimen in our possession, procured from the Naples Zoological Station and labeled by them *P. elegans*, seems to merit a separate treatment in this rather detailed study of the entire group. It is possible that this is nothing more than a colony of *P. atlanticum giganteum;* but, if so, it is the only specimen of this form which we have studied which is so perfectly transparent and colorless,[1] and which bears such extremely long and numerous test processes. It is probable, but not definitely known, that this specimen was taken from the Mediterranean Sea. Apparently this form is identical with the Naples species referred to by Krüger (1912, p. 6) as *P. elegans,* which he says is characterized by extremely long oral siphons. There is no indication that this is the form to which Lesueur originally gave the name *elegans*. To avoid confusion, it seems best not to use this name. Krüger's reference is insufficient for certain identification of the form he had.

The colony is a thick, cylindrical tube, and tapers but slightly toward the closed end; its widest part is near the middle. The dimensions are: length 12.5 cm., width at open end 2.8 cm., at middle 3 cm., at closed end 2 cm. The test is transparent, the whitish zoöids giving to the whole colony a white appearance. Nearly all the test processes are long and fingerlike, and bend in the direction of the colonial aperture. At their ends they are not sharply pointed, but are narrow, and in edge view for the most part emarginate, being narrowed on the outward side. They average about 8 mm. in length, the largest of them attaining 1.3 cm.

Each of the more mature zoöids has an extended oral-siphon, opening onto a test-process, near its tip. These zoöids are narrow and tube-like, reaching a length of 0.9 cm.-1.9 cm. The less mature individuals average 0.6 cm. long; they appear slender and ovoid, width 1.8 mm. to 2.5 mm. The cloaca is long, in this form, usually about two-thirds the length of the branchial sac, which is 3 mm. to 3.5 mm. long. The cloaca is often found to be quadrangular in cross-section. There is extreme diversity as to the size and shape of the oral chamber, but it takes the form of a long, slender siphon in the majority of cases. Two circum-oral fibres can be seen, not always reaching completely around the oral chamber; the anterior one is sometimes abortive or very much constricted.

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[1] Our specimen is preserved in alcohol.

The luminous organs in this form are large and distinct. They are circular or quadrangular, but vary greatly in size, even those on the two sides of the same zoöid being of different sizes in some instances. In each branchial wall, which is long and elliptical, there are 16-17 longitudinal bars and 30-36 stigmatal rows. The endostyle never describes a very strong curve. The dorsal languets number from 8 to 9. The digestive tract is small, but in other respects is as usual for the species *atlanticum*.

The testis consists of a large number of lobes, 20-26, some of which may again be partially divided into secondary lobes or pouches. The entire organ becomes large and prominent when mature. We find the condition of protogyny almost universal among the zoöids of this one colony. Perhaps smaller ones would be found to contain a greater proportion of protandrous individuals.

Our knowledge of the occurrence of this form is based upon the single specimen obtained from the Naples Zoological Station. It is probable that it was secured in the Bay of Naples, or in the Mediterranean Sea, but its label bears no statement of the place of collection. This specimen has been deposited in the United States National Museum, and bears Cat. No. 6437 (Type) U.S.N.M.

GENERAL CONSIDERATIONS.

RELATIONSHIPS WITHIN THE FAMILY.

The accompanying chart indicates some possible relationships among the *Pyrosomata ambulata*, and also their apparent centers of distribution. The subspecies *atlanticum*, seems to be the parent form for the whole *atlanticum* group. Its home is apparently the Pacific Ocean. The smooth forms are shown as a distinct group, some members of which, however, interbreed with the *atlanticum* group; thus, we have four colonies which seem to be hybrids between *P. atlanticum atlanticum* and *P. verticillatum*, subspecies *cylindricum*.[1] If the form *dipleurosoma* is to be regarded as a distinct subspecies of *atlanticum*, we would have to say, from the evidence in our collections, that this subspecies interbreeds with *atlanticum atlanticum*.[2]

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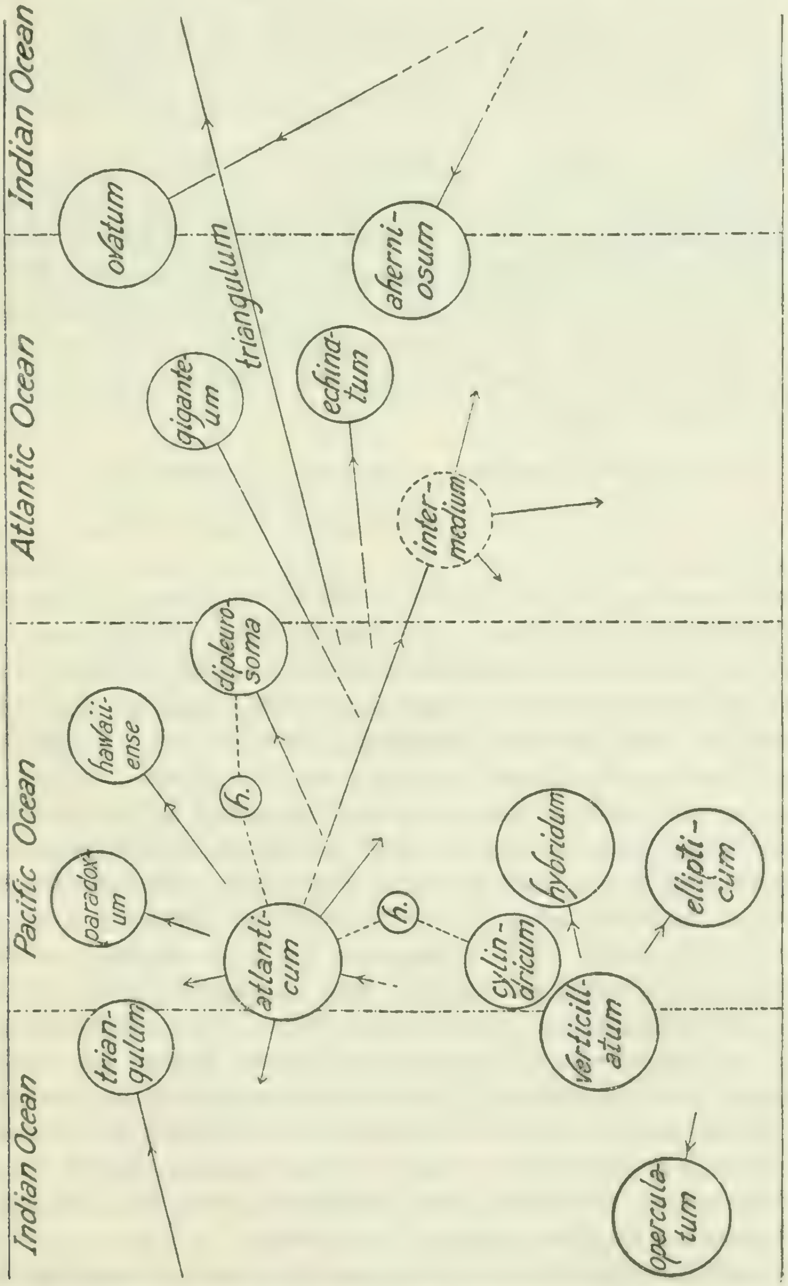
[1] United States National Museum, Cat. Nos. 6118 (*type*) and 6417.
[2] Idem, Cat. Nos. 6471 (*type*) and 6421.

and probably with its subspecies *paradoxum*,[1] as well as with members of the group "*intermedium*"; but a better expression of the conditions seems to be to say that any of these forms mentioned may be flattened, that is, may take on the *dipleurosoma* condition. In the chart, the small circles containing the letter "*h*" indicate forms in our collection interpreted as hybrids.


Indian Ocean
Atlantic Ocean
Pacific Ocean
Indian Ocean
ovatum
aherni-osum
triangulum
gigante-um
echina-tum
inter-medium
dipleuro-soma
hawaii-ense
h.
paradox-um
atlanti-cum
h.
cylin-dricum
hybridum
ellipti-cum
verticill-atum
trian-gulum
opercula-tum

SCHEME OF PROBABLE ORIGIN AND DISTRIBUTION OF THE PYROSOMATA FIXATA.

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[1] United States National Museum, Cat. Nos. 6469 (*type*) and 6420.

The probable derivation of the *atlanticum* group from the group of smooth species, *verticillatum*, *hybridum*, *ellipticum*, and *operculatum*, is indicated by the fact that the young colonies of *atlanticum* and its subspecies are for a time smooth; that is, their test processes, at least in some colonies, develop rather late. The zoöids in young *atlanticum* colonies are short and more nearly round, as they are in the smooth species, excepting of course the considerably aberrant *operculatum*.

The subspecies *triangulum* resembles some of the Atlantic specimens of *atlanticum*, notably certain colonies of the group *intermedium*, more nearly than it does the Pacific forms. Like the former it has a considerably roughened test surface and its zoöids are short and angular. Because of these indications of nearer relationship to the Atlantic forms, the line of derivation for the subspecies *triangulum*, in the chart, is carried through the Atlantic Ocean into the Indian and Pacific Oceans.

ORIGIN AND RELATIONSHIPS OF THE FAMILY PYROSOMIDAE.

The origin and relationships of *Pyrosoma* should receive a word of discussion in any taxonomic paper upon the group. *Pyrosoma*, in its adult anatomy, shows no clear indication of close relationship to the Doliolidae or Salpidae, and classing these pelagic forms all in one major group, as is sometimes done, is hardly justified. On the other hand *Coelocormus* (Herdmann, 1886) and *Cyathocormus* (Oka, 1913), in their structure, suggest a probable origin of the free swimming Pyrosomidae from the Compound Ascidians. Indeed, if a detached cylinder of *Cyathocormus* had happened to be discovered before the whole attached colony was known, it would have been classed with the Pyrosomidae, rather than with other Compound Ascidians, on account both of the form of the colony and of the structure of the zoöid. The anatomical evidence in favor of this relationship seems very convincing, but thorough studies of the processes of budding and colony formation in *Coelocormus*, and especially in *Cyathocormus*, are greatly needed before we can be certain that *Cyathocormus* and *Pyrosoma* have reached their peculiar form in similar ways and are truly comparable in their structure.

Cyathocormus is regarded by Oka as most nearly related to the Distomidae among the Compound Ascidians, and this conclusion appears borne out by the comparative anatomy.

The Pyrosomidae should, therefore, pending study of budding and colony formation in *Cyathocormus*, be classed as a divergent group of the Compound Ascidians.[1]

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[1] For fuller discussion of the relationships among the *Tunicata* see Metcalf and Bell (1918).

SPECIATION.

As noted in the introduction to this paper, one of the features of *Pyrosoma*, of chief interest, is the remarkable intergradation shown between its different forms, and this is the more impressive when one compares this family with the family Salpidae, whose species are sharply distinct from one another. The conditions among the Pyrosomas suggest hybridization as a factor cooperating with mutation to produce the results observed. In the *atlanticum* group, at least, hybridization seems probably to be continuing to-day.

The differences between species are far greater among the Salpidae than among the Pyrosomidae. Lack of physiological isolation within the latter group has probably aided to prevent extreme divergence, but the inherent tendencies to divergence were doubtless also less. *Pyrosoma* is a remarkably stable form, its several species and subspecies differing from one another but slightly, and this chiefly in size of colony and in the character of the test processes, in the relative proportions of the series of three respiratory chambers in the zoöids, and in the number of stigmata and of branchial bars.

INDIVIDUALITY AND FORM CONTROL.

Another keenly interesting feature in *Pyrosoma* is the way it presents the universal problems of form control and of individuality, two very closely related conceptions. *Pyrosoma*, like all other colonial organisms, has three grades of individuality, that of the cell, that of the zoöid and that of the colony, but it is peculiarly interesting in that the individuality of the cell is not only subordinated to that of the zoöid, but is also, in the case of some cells, directly subordinated to the colony as a whole, without reference to the zoöids. This feature is best seen in connection with the form and sculpturing of the colonial test.

Note first a feature characterizing the oral test processes in *Pyrosoma atlanticum atlanticum* (fig. 30, pl. 26, and fig. 33, pl. 28), or in *P. ovatum* (fig. 29, pl. 25). Each elongated test process is obliquely truncated distally, the area of truncation being smooth and nearly flat, and containing the oral aperture. Outside the truncate surface, the tip of the oral test process bears numerous minute denticles, at the base of each of which lies a test cell, which doubtless either secretes the test material of which the denticle is composed, or so influences its arrangement that it takes the form of a denticle. These test cells are mesenchyme cells, which have wandered outside the zoöids in which they arose, have migrated to a distance, and have each taken up a definite position in the test at a distance from the zoöids, there to form or control the formation of a denticle, a minute protruding bit of test substance. They take their position, not on the area of truncation, but at rather regular intervals around its edge and over the tip of the oral test process. These test cells are not connected with any nerve fibrils, and they are not in contact with any zoöid or any other cells, yet each produces, or causes to be produced, at the proper place on the surface of the test, the particular bit of sculpturing for which it is responsible.

Other similar denticles are found over the surface of the test, not in relation to oral processes or the zoöids. The cells which form these scattered denticles are acting in relation, not to the zoöids, but to the colony as a whole. It is the "soul" of the colony, and not of any zoöid, to which in their activity they are each subservient.

But we find more remarkable illustration of form control, in the case of the four quadrangular tentacle-like processes at the open end of the colony in *Pyrosoma agassizi* (fig. 6, pl. 18). These are not connected with any particular zoöids or groups of zoöids. They are composed of the cellulose test material with a few scattered test cells within them. Like the rest of the test, their material is nonliving substance. The test is secreted chiefly, or it may be wholly, by the ectodermal epithelium, the share of the test cells in this function being doubtful. How can these quadrangular test "tentacles", which apparently must elongate by growth at their bases, be so controlled that they assume their very definite quadrangular tapering form and lie in their four appointed places at the open end of the colonies, their outer and lateral angles being continued as ridges back over the surface of the colony, well toward its closed end?

Assuming for the moment that the formation of the four test "tentacles" is controlled by test cells, we find again an illustration of subservience of isolated cells to the colony as a whole and not to the zoöids from which they arose. The "sense of form" (!) which these cells possess has reference not to themselves, nor to the zoöids of which they were constituent parts, but to the colony as a whole, although they are isolated cells, lying at an appreciable distance from other cells or tissues, and not connected with any nerve fibrillae.

Or, choosing the other possibility and disregarding the doubtful activity of the test cells, we may say that the test substance composing these test "tentacles" is secreted by a number of small, discrete areas of ectoderm, the ectoderm of the several zoöids. The characteristic features of form of these "tentacles" are superficial and therefore separated by an appreciable distance, the thickness of the test, say 1–2 cm., from the secreting cells. How can the behavior of the test material, after it is formed, be so controlled that it assumes the proper relations of form and position, so that "tentacles" of the characteristic type and in the characteristic position, result? The test material is not alive, yet, at a distance from the cells which secrete it, it molds itself into particular form and takes a definite position in the colony. This seems an even more remarkable instance of the "feeling for form" permeating the whole colony and affecting even the nonliving, secreted material of which the colony is in large part composed. Of course, this figurative manner of expressing the point is false in its implications. The thing of moment is, that if the test cells be not active in secreting the test substance or in controlling its modeling, then there is some type of control which affects not only the living cells of the ectodermal epithelia of the zoöids, but the secreted test substance as well, and the reaction has relation to the form of the colony as a whole and not to its constituent zoöids.

There is a further point of some interest. On the hypothesis of the direct response of the secreted test substance to controlling influences, causing it to take the definite form and positions characteristic of the four test "tentacles," we must say that these controlling influences are in the nature of tropisms and the response is a nonvital one. Of course, it is wholly probable that these tropisms themselves are established through the vital activities of the living constituents of the colony, but the response of the secreted material, which causes it to take definite form and position, is a nonvital response. If a structure so definite in form and position as one of these test "tentacles" is formed under the control of stimuli external to itself, by a response evidently nonvital, it suggests how intimate and how intimately controlling may be the influence of such tropisms upon living substance in this and other organisms.

Whether the test cells be active (first hypothesis) or inactive (second hypothesis) in the secretion of test material, *Pyrosoma* presents peculiarly interesting conditions. The behavior of the isolated test cells in *Pyrosoma atlanticum* and the formation of the test sculpturings, especially the ridges and "tentacles" of *Pyrosoma agassizi*, are even more mysterious than the behavior of migrating cells and tissues in the embryonic development of organisms, for there is in the former less of organic contact. We do not see that we are as yet in possession of data that enable us to make any suggestion as to the nature of the control over these phenomena. The problem, however, is presented in *Pyrosoma* in a most striking way that challenges attention.

GEOGRAPHICAL DISTRIBUTION.

The distribution of each species and subspecies of *Pyrosoma* has been stated in connection with our description of its structure, but it is well to bring the data together. The accompanying table shows the localities from which each form has been reported, and the authority for the statement. Where no authority is mentioned, the statement is based upon the collections of the United States Bureau of Fisheries and the United States National Museum, discussed in this paper. The question marks are explained each in a foot note.

Name.	Indian Ocean.	North Pacific Ocean.	South Pacific Ocean.	South Atlantic Ocean.	North Atlantic Ocean.	Mediterranean Sea.	Antarctic Ocean.
P. agassizi	× Neumann	×	× Ritter&B.	× Neumann			
P. spinosum	× Bonnier&P.	×		× Herdman	×		
P. verticillatum	× Neumann	?[1] Neumann					
P. verticillatum cylindricum		×					
P. hybridum		×					
P. ellipticum		×					
P. operculatum	× Neumann						
P. aherniosum	× Neumann	?[2] Herdman		× Neumann	× Seeliger		
P. ovatum	× Neumann			× Neumann			
P. atlanticum	× Neumann	× Ritter	×	?[3]	?[4] Seeliger	?	
P. atlanticum hawaiiense		×					
P. atlanticum paradoxum		×					
P. atlanticum diplevrosoma					Brooks		
P. atlanticum giganteum				×	×	?[6]	Herdman
P. atlanticum echinatum						×[7]	
P. atlanticum triangulum	Neumann						

[1] This may have been of the subspecies *cylindricum*, which is the Pacific form in our collections.

[2] The identification of this small specimen is a little doubtful.

[3–5] The descriptions of these Atlantic forms do not show clearly the features we have taken as distinctive of *P. atlanticum atlanticum*. This species may very likely occur in the Atlantic Ocean, but it is equally likely that the Atlantic forms are of the sorts which we have grouped under the name *intermedium*, which does not represent a single, true subspecies.

[6] The subspecies *giganteum* occurs in the Atlantic Ocean, and it is probable that the reports of "*giganteum*" from the Mediterranean Sea apply properly to this subspecies.

[7] Our colony of this form, obtained from the Naples Zoological Station, was probably collected in the western Mediterranean Sea, but it bears no locality label.

A complete statement of the stations represented in our collections, arranged by species and subspecies, follows. When more than a single specimen was found, the number of specimens is given in brackets (as [4]) after the station.

PYROSOMA AGASSIZI.

Nine dredging stations from the *Albatross* Philippine Expedition, 1907–1910, as follows: 5126, 5233, 5320, 5378, 5458, 5498, 5514, 5543, 5607, all from among or near the Philippine Islands, and from off the Pacific coast of Panama, at station 3388 (*Albatross*) [3].

PYROSOMA SPINOSUM.

Albatross Philippine dredging stations 5613 and 5631, and station 2228 (*Albatross*), in Vineyard Sound, off the Massachusetts coast.

PYROSOMA VERTICILLATUM, subspecies CYLINDRICUM.

Albatross Philippine dredging stations 5120, 5125 [7], 5320, 5456[10], 5437 [2], all among or near the Philippine Islands.

PYROSOMA HYBRIDUM.

Albatross Philippine dredging stations 5238 [2], 5320 [11], 5457 [2], 5458, all among the Philippine Islands.

PYROSOMA ELLIPTICUM.

Albatross Philippine dredging station 5319, in the northern China Sea; and three small colonies of doubtful identification from station 3788, AA 15 (*Albatross*), latitude 4° 35′ N.; longitude 136° 54′ W., 600 miles north of the Marquesas Islands.

PYROSOMA ATLANTICUM ATLANTICUM.

Albatross Philippine Expedition, 17 dredging stations among and near the Philippine Islands (5120 [13], 5125[3], 5128[13], 5155, 5175[4], 5183, 5195, 5223, 5263, 5299, 5331[4], 5366, 5409[5], 5410[3], 5437[12], 5613, and an unnumbered station "Jolo anchorage"); *Albatross* station 5064[12]; an unnumbered station off La Jolla, California, [3] (Ritter); a station of the Carnegie Magnetic Expedition, between Hawaii and California, not more accurately located; a specimen bearing a label of Ward's Natural Science Establishment, giving the locality merely as "South Pacific"; and two small specimens, of doubtful identification, from *Albatross* stations D 5124, in the Philippine Islands, and 3750, off Honshu, Japan.

PYROSOMA ATLANTICUM, subspecies HAWAIIENSE.

A station of the Carnegie Magnetic Expedition, between Hawaii and the California coast, not more accurately stated [6].

PYROSOMA ATLANTICUM, subspecies PARADOXUM.

An unnumbered station of the *Albatross* Philippine Expedition, Lat. 25° 10′ N., Long. 166° 20′ W.

PYROSOMA ATLANTICUM, form DIPLEUROSOMA.

Five dredging stations of the *Albatross* Philippine Exhibition, all among the Philippine Islands, 5196[2], 5262[3], 5398[2], 5403[2], 5408[5], and a specimen bearing a label of Ward's Natural Science Establishment, naming the locality merely as "South Pacific."

PYROSOMA ATLANTICUM, subspecies GIGANTEUM.

Eleven dredging stations in the western north Atlantic Ocean, from the Bahamas to Cape Cod (*Albatross*, 2088, 2089, 2091, 2094, 2171,

2381. 2655. 2668. 2674. 2714. and an unnumbered station 240 miles east of Cape Cod): a station in the Gulf of Mexico, 2381 (*Albatross*) and one in the Straits of Florida, 2642 (*Albatross*) [2]; and two stations, probably in the western north Atlantic Ocean, 7518 and 7519 (*Fish Hawk*).

PYROSOMA ATLANTICUM, group INTERMEDIUM.

Nine *Albatross* stations in the western north Atlantic Ocean, from Florida to Cape Cod (2039, 2058[2], 2092, 2602, 2626[2], 2667, 2669, 2673, 2675), and two stations in the Gulf of Mexico, off the Florida coast (2396, *Albatross*, and an unnumbered station "off Pensacola").

PYROSOMA ATLANTICUM, subspecies ECHINATUM.

A colony from the Naples Zoological Station, labeled "*Pyrosoma elegans*," probably from the western Mediterranean Sea.

PYROSOMA ATLANTICUM, subspecies TRIANGULUM.

Albatross Philippine Stations D 5402 and D 5410, in Philippine waters, and an unnumbered station off Honshu, Japan.

At several stations more than one species was collected. This is of some interest as showing the possibility of hybridization. A list of these stations, with the species collected from each, is as follows: *Albatross* dredging stations in Philippine waters—5120, *Pyrosoma atlanticum atlanticum* and *P. verticillatum cylindricum;* 5125, the same forms; 5320, *P. agassizi* and *P. hybridum;* 5410, *P. atlanticum atlanticum* and *P. atlanticum triangulum;* 5437, *P. atlanticum atlanticum* and *P. vercillatum cylindricum;* 2458, *P. agassizi* and *P. hybridum;* 5613, *P. atlanticum atlanticum* and *P. spinosum;* Carnegie Magnetic Expedition, unnumbered station, between Hawaii and California, *P. atlanticum atlanticum*, and *P. atlanticum hawaiiense;* and an unnumbered station in the "south Pacific" Ocean, *P. atlanticum atlanticum* and *P. atlanticum*, form *dipleurosoma*.

LITERATURE CITED.

Bonnier and Perez (1902). Sur un nouveau Pyrosome gigantesque. Comp. rend. Acad. Sci., vol. 134.

Brooks (1906). Dipleurosoma, a new genus of Pyrosoma. Johns Hopkins Univ. Circ., vol. 26, p. 5.

——— (1906). The affinities of the pelagic Tunicates. No. 1. On a new Pyrosoma (Dipleurosoma elliptica). Mem. National Acad. Sci., vol. 10.

Burghause (1914). Kreislauf und Herzschlag bei Pyrosoma giganteum nebst Bemerkungen zum Leuchtvermögen. Zeitschr. f. w. Zoologie, vol. 108, p. 430.

Farran (1906). On the distribution of the Thaliacea and Pyrosoma in Irish waters. Report of the Sea and Inland Fisheries of Ireland for 1896, pt. 2, Appendix I.

Grobben (1882). Doliolum und sein Generations wechsel. Arb. zool. Inst. zu Wien., vol. 4, p. 2.

Herdman (1886). Report on the Tunicata collected during the voyage of H. M. S. *Challenger*, during the years 1873–76. II Ascidiae compositae. Zool. *Challenger* Exped., vol. 14, pt. 38.

——— (1888). Report upon the Tunicata collected during the voyage of H. M. S. *Challenger*, during the years 1873–76. III Ascidiae Salpaeformes, Thaliacea, Larvacea, etc. Zool. *Challenger* Exped., vol. 27, pt. 76.

Hunter (1898). Notes on the peripheral nervous system of Molgula manhattensis. Journ. Comp. Neurology, vol. 8.

Huxley (1851). Observations upon the anatomy and physiology of Salpa and Pyrosoma. Philos. Trans. Roy. Soc., 1851.

——— (1860*a*). On the anatomy and development of Pyrosoma. Trans. Linn. Soc. Lond., vol. 24 (1862), p. 1.

——— (1860*b*). On the development of Pyrosoma. Ann. Nat. Hist. (3) vol. 5.

——— (1861). On the nature of the earliest stages of the development of animals, Proc. Roy. Inst., vol. 3 (1862).

Joliet (1888). Etudes anatomiques et embryogeniques sur le Pyrosoma giganteum, suives de recherches sur la faune de Bryozoaires de Roscoff et de Menton. Paris, 1888.

Julin (1912). Recherches sur le devéloppement embryonnaire de Pyrosoma giganteum. Les. Zool. Jahrbücher. Supplement XV, 2 vols.

Keferstein and Ehlers (1861). Zoologische Beiträge gesammelt im Winter 1859–60 in Neapel und Messina. III Ueber die Anatomie und Entwicklung von Doliolum: IV, Bemerkungen über die Anatomie von Pyrosoma. Leipsig, 1861.

Korschelt and Heider (1900). Textbook of the Embryology of Invertebrates Trans. by Bernard and Woodward, vol. 4.

Kowalevsky (1875). Ueber die Entwicklungsgeschichte der Pyrosoma. Archiv. f. mikrosk. Anat., vol. 11.

Krüger (1912). Pyrosomes et Appendiculaires provenant des campagnes de *l'Hirondelle* et de la *Princesse-Alice* (1885–1910). Resultats des campagnes scientifiques accomplies sur son yacht par Albert Ier, Prince Soverain de Monaco. Fasc. 39. Monaco, 1912.

Lesueur (1813). Memoire sur quelques nouvelles especis d'Animaux mollusques et radiares recueillis dans la Mediterranee pres de Nice. Nouv. Bull. Soc. Philom. vol. 3; also Journ. Physique, vol. 77.

——— (1815). Memoire sur l'organisation des Pyrosomes. Bull. Soc. Philom., 1815; also Journ. Physique, vol. 80.

Metcalf (1904). Neritina virginea, variety minor. Amer. Naturalist, vol. 38.

Metcalf and Bell (1918), The Salpidae, a Taxonomic Study. The second paper of this volume.

Neumann (1908). Mitteilungen über eine neue Pyrosomen-Art der Deutschen Tiefsee-Expedition (Pyrosoma operculatum). Zool. Anzeig., vol. 33.

——— (1909–1913). Die Pyrosomen, Bronn's Klassen und Ordnungen des Tier-Reichs. Vol. 3, Suppl. 2, Abth. 2.

——— (1909*a*). Mitteilung über eine neue Pyrosomen-Art der Deutschen Tiefsee-Expedition (P. triangulum). Zool. Anzeig., vol. 33.

——— (1909*b*). Mitteilung über eine neue Pyrosomen-und Doliolum-Art der Deutschen Südpolar-Expedition. Zool. Anzeig., vol. 33.

——— (1909*c*). Mitteilung über eine neue Pyrosomen-Art der Deutschen Tiefsee-Expedition (P. verticillatum), nebst Bemerkungen über die Stockbildung und des Wandern der Knospen bei Pyrosomen. Zool. Anzeig., vol. 34.

——— (1912). Über Bau und Entwicklung des Stolo prolifer der Pyrosomen. Zool. Anzeig., vol. 39.

——— (1913*a*). Die Pyrosomen der Deutschen Teifsee-Expedition. Wissensch. Ergebn. der Deutschen Tiefsee-Expedition, vol. 12, p. 4.

NEUMANN (1913*b*). Die Pyrosomen der Deutschen Südpolar-Expedition. Deutsche Südpolar-Expedition, vol. 14, p. 1.

OKA (1912). Eine neue phylogenetisch interessante Synascidie (Cyathocormus mirabilis, n. g., n. sp.). Zool. Anzeig., vol. 40, 10/11, Oct., 1912.

——— (1913). On Cyathocormus mirabilis, nov. gen., nov. sp., The Type of a New Family of Compound Ascidians, from Japan. Journ. of Coll. of Science. Imperial Univ., of Tokyo, vol. 32, art. 12.

PERON (1804). Memoire sur le nouveau genre Pyrosoma. Ann. Mus. Hist. nat. vol. 4, and Journ. Physique, vol. 61.

RITTER (1905). The Pelagic Tunicata of the San Diego Region, excepting the Larvacea. Univ. of California Publ., Zool., vol. 2, p. 3.

RITTER AND BYXBEE (1905). Reports on the scientific results of the Expedition to the Tropical Pacific in charge of Alexander Agassiz, in the United States Fish Commission steamer *Albatross*, VIII. The Pelagic Tunicata. Mem. Mus. Comp. Zool., vol. 26, p. 5.

SALENSKY (1891). Beiträge zur embryonalentwicklung der Pyrosomen. Zool, Jahrb. Anat., vol. 5, p. 1.

DE SAVIGNY (1816*a*). Memoires sur les Animaux sans Vertebres. Paris, 1816.

——— (1816*b*). Description de l'Egypte. Histoire Naturelle, I, 2. Tableau systematique des Ascidies, tant simples que composies, etc. Paris, 1816 (dated 1809).

SEELIGER (1895). Die Pyrosomen der Plankton-Expedition. Ergebn. der Plankton-Expedition der Humboldt-Stiftung, vol. 2, E, b. Kiel and Leipsig, 1895.

ULJANIN (1884). Die Arten der Gattung Doliolum im Golfe von Neapel und den angrenzenden Meeresabschnitten. Fauna und Flora des Golfes von Neapel, vol. 10. Leipsig, 1884.

USSOW (1876). Contributions to the knowledge of the organization of the Tunicata [Russian]. Trans. Nat. Soc. Moscow, vol. 18, p. 2.

EXPLANATION OF PLATES.

Reference letters used on plates and text figures.

1–8=nerves.
a.=anus.
b.=bud.
b. o.=blood-forming organ.
br. b.=branchial bars.
br. c.=branchial chamber.
br. c′.=prebranchial chamber.
c. a.=colonial aperture.
c. f.=ciliated funnel.
cl.=cloaca.
cl. a.=cloacal aperture.
cl. m.=cloacal muscle.
cl. tn.=cloacal tentacle.
c. m.=circum-oral muscle.
d.=diaphragm.
d. a. s.=dorsal anterior blood sinus.
d. l.=dorsal languet.
d. l. s.=dorso-lateral blood sinus.
d. p. s.=dorsal posterior blood sinus.
d. s.=dorsal blood sinus.
dt.=duct of neural gland.
e.=endostyle.

en.=enteron.
f. c.=follicle cell.
g.=ganglion.
gl.=neural gland.
g. s.=posterior gonadial sinus.
h.=heart.
int.=intestine.
l. m.=ventral lateral muscular system.
l. m′.=dorsal lateral muscular system.
l. o.=luminous organ.
l. o′.=cloacal luminous organ.
m.=mouth.
n.=nerve.
n.1–n.8=nerves.
nc.=nucleus.
n. r.=neural rudiment.
o.=ovary.
od.=oviduct.
oc.=esophagus.
oc. a.=esophagal aperture.
op.=operculum.
ov.=ovum.
p.=pigment.
p. a.=primary ascidiozoöid.
pbr.=peribranchial chamber.
pc.=pericardium.
pc′.=pericardial tube.
ph.=pharynx.
ph. b.=peripharyngeal band of cilia.
ph. s.=peripharyngeal blood sinus.
py.=pylorus.
r. v.=reniform vesicle.
s.=stolon.
s′.=stolon process.
s. s.=stolon blood sinus.
st.=stomach.
stg.=stigma.
t.=testis.
t. f.=test fibre.
tn.=tentacle.
t. p.=test process.
t. s.=blood sinus to tunic.
v. a. s.=ventral anterior blood sinus.
vc. s.=visceral sinus.
v. d.=vas deferens.
v. l. s.=ventro-lateral blood sinus.
v. s.=ventral blood sinus.
y.=yolk.

PLATE 15.

Pyrosoma atlanticum.

FIG. 1.—A schematic figure of a zoöid, showing internal organization. After Burghause (1914).

PLATE 16.

Pyrosoma agassizi.

FIG. 2.—An oral view of the mouth region of a zoöid, showing tentacles, sphincter muscles, lateral muscles, nervous system, peripharyngeal bands and tip of endostyle. After Neumann (1909–1913).

3.—A nearly adult zoöid, seen from the left side. × 25.

PLATE 17.

Pyrosoma agassizi.

FIG. 4.—A posterior view of a nearly adult zoöid. × 25.

5.—The nervous system, exclusive of the oral region. After Neumann (1909–1913).

PLATE 18.

Pyrosoma agassizi.

FIG. 6.—The open end of a colony. After Ritter and Byxbee (1905).

7.—A young zoöid, seen from the left side. × 42.

PLATE 19.

Pyrosoma spinosum.

FIG. 8.—An adult zoöid, seen from the left side. × 17.

PLATE 20.

Pyrosoma spinosum.

FIG. 9.—A postero-ventral view of the posterior end of an adult zoöid. × 21.

10.—The reniform vesicle and adjacent organs, seen from the left side. × 28.

PLATE 21.

FIG. 11.—*Pyrosoma spinosum: A*, an embryo with unsegmented stolon. × 18 *B*, an embryo with the four primary ascidiozoöids appearing as buds upon the stolon × 56.

12.—*P. verticillatum:* An adult zoöid, seen from the left side. × 21. After Neumann (1909*c*).

PLATE 22.

FIG. 13.—*Pyrosoma verticillatum:* The oral region of a zoöid, showing chiefly the nervous system. After Neumann (1909–1913).

14.—*P. verticillatum cylindricum:* Colony. × 2.

15. *P. verticillatum cylindricum:* An adult zoöid, seen from the left side. × 21.

PLATE 23.

FIG. 16.—*Pyrosoma hybridum:* Colony. × 2.

17.—*P. hybridum:* An adult zoöid, seen from the left side. × 21.

18.—*P. ellipticum:* An adult zoöid seen from the left side. × 21.

19.—*P. ellipticum:* Colony. Natural size.

20.—*P. ellipticum:* The same colony as that shown in figure 19, seen from the open end. Natural size.

PLATE 24.

FIG. 21.—*Pyrosoma operculatum:* Colony. $\frac{2}{3}$ natural size. After Neumann (1908).

22.—*P. operculatum:* A nearly adult zoöid, seen from the left side. ×13. After Neumann (1908).

23.—*P. operculatum:* The end of the cloacal siphon, showing the opercular fold partly closed. ×15. After Neumann (1908).

24.—*P. aherniosum:* An adult zoöid, seen from the right side. ×25. After Seeliger (1895).

25.—*P. aherniosum:* The viscera of a young zoöid (testis immature), seen from the left side. ×52. After Seeliger (1895).

PLATE 25.

Pyrosoma ovatum.

FIG. 26.—The oral end of an adult zoöid of the elongated sort, seen from the left side. After Neumann (1913 *b*).

27.—An adult zoöid of the shorter sort, seen from the left side. ×11. Modified from Neumann (1909 *b*).

28.—A sagittal section through the distal end of the oral siphon of a zoöid of the elongated sort. ×11. After Neumann (1909 *b*).

29.—A somewhat ventral view of the distal end of an oral siphon of a zoöid of the elongated sort. ×24. After Neumann (1913 *b*).

PLATE 26.

Pyrosoma atlanticum atlanticum.

FIG. 30.—An adult zoöid, seen from the left side. ×21.

PLATE 27.

Pyrosoma atlanticum atlanticum.

FIG. 31.—The posterior end of an immature zoöid, from a large colony, seen from the left side. ×32.

32.—A young zoöid from a small colony, seen from the left side. This was the most nearly mature zoöid in the colony. ×21.

PLATE 28.

FIG. 33.—*Pyrosoma atlanticum atlanticum:* An outline drawing of a ventral view of an oral process of an adult zoöid.

34.—*P. atlanticum hawaiiense:* A nearly adult zoöid, seen from the left side. ×15.

PLATE 29.

FIG. 35.—*P. atlanticum paradoxum:* An adult zoöid, seen from the left side. ×21.

36.—*P. atlanticum triangulum:* An adult zoöid, seen from the left side. × about 11. After Neumann (1909 *a*).

PLATE 30.

Pyrosoma atlanticum giganteum.

FIG. 37.—An adult zoöid from a large colony, seen from the left side. ×19.

PLATE 31.

Pyrosoma atlanticum echinatum.

FIG. 38.—A mature zoöid of the sort without an elongated oral siphon. ×21.

PLATE 32.

Pyrosoma atlanticum, form *dipleurosoma*.

FIG. 39.—A colony, seen from the flattened face. ×⅔. After Brooks (1906).

40.—An edge view of a colony. ×⅔. After Brooks (1906).

41.—The open end of a colony. ×⅔. After Brooks (1906).

PLATE 33.

FIG. 42.—*Pyrosoma agassizi:* An unretouched photograph of a colony. ×1½.

43.—*P. verticillatum cylindricum:* An unretouched photograph of a colony. ×2.

44.—*P. ellipticum:* An unretouched photograph of a colony. ×1½.

PLATE 34.

FIG. 45.—*Pyrosoma atlanticum atlanticum:* An unretouched photograph of a colony. About natural size.

46.—An unretouched photograph of the open end of the colony shown in figure 45. Slightly enlarged.

47.—*P. atlanticum*, form *dipleurosoma:* An unretouched photograph of a twisted colony, partly in edge view, partly in face view. About natural size.

PLATE 35.

FIG. 48.—*Pyrosoma atlanticum echinatum:* An unretouched photograph of a colony. About natural size.

49.—*P. atlanticum hawaiiense:* An unretouched photograph of a colony. About natural size.

PLATE 36.

FIGS. 50–53.—*Pyrosoma atlanticum*, subspecies doubtful, figure 53 shows a form resembling the type of the species: Retouched photographs of young colonies. The open ends of the colonies are toward the top of the plate except in figure 51, which is a view of the closed end of the same colony that is shown in figure 50. × about 1½.

54.—*P. hybridum*, a retouched photograph, showing the flattened face of the colony ×1¼.

55.—A retouched photograph, in edge view, of the same colony as that shown in figure 54. ×1¼.

This manuscript was completed for the United States Bureau of Fisheries on July 10, 1915, and received for publication by the United States National Museum on February 21, 1917.

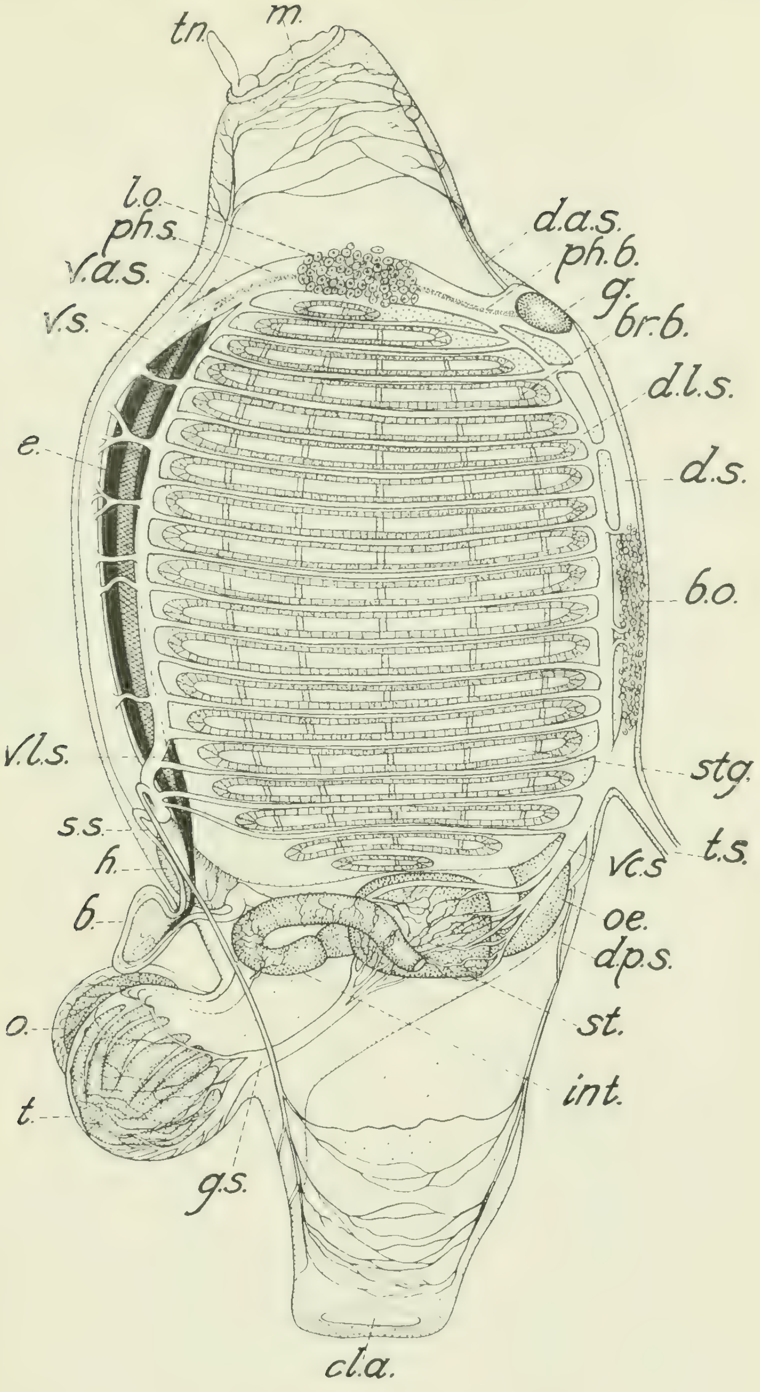
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Fig. 1.

PYROSOMA ATLANTICUM.

FOR EXPLANATION OF PLATE SEE PAGE 270.

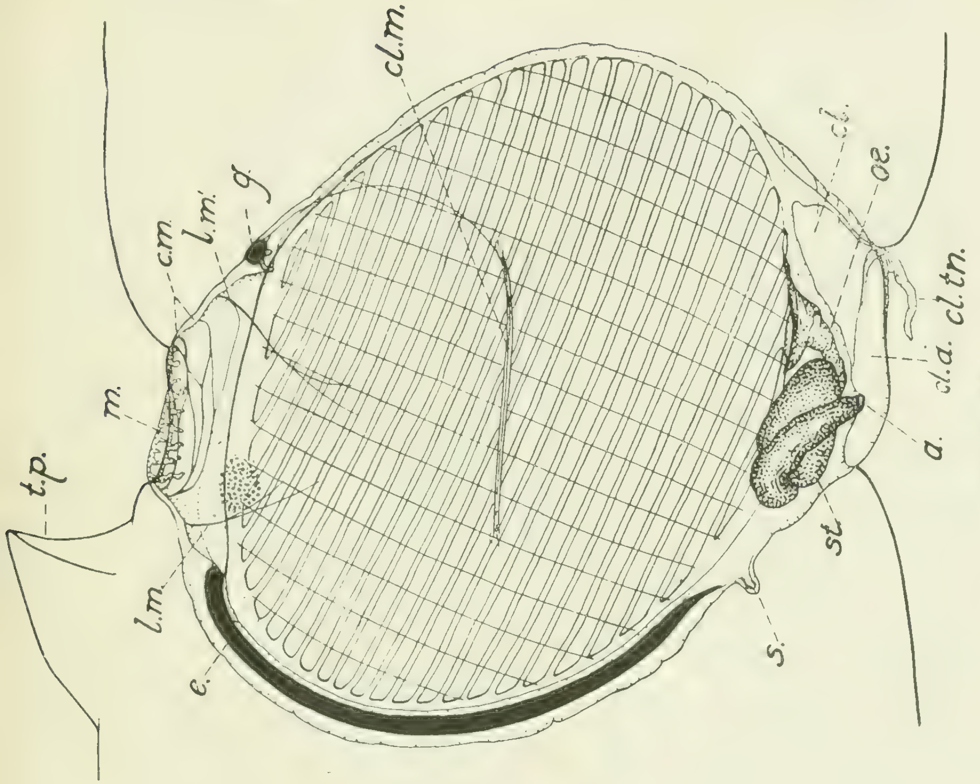
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Fig. 3

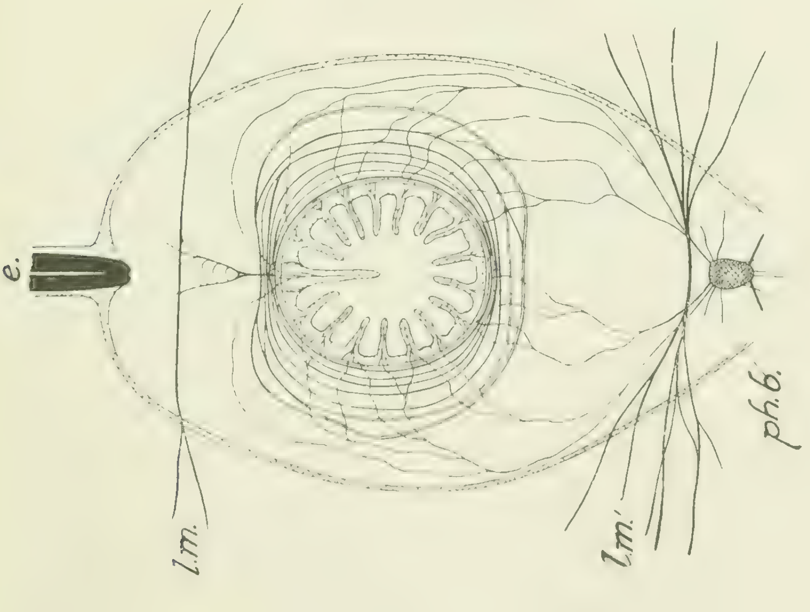

Fig. 2.

PYROSOMA AGASSIZI.

FOR EXPLANATION OF PLATE SEE PAGE 270

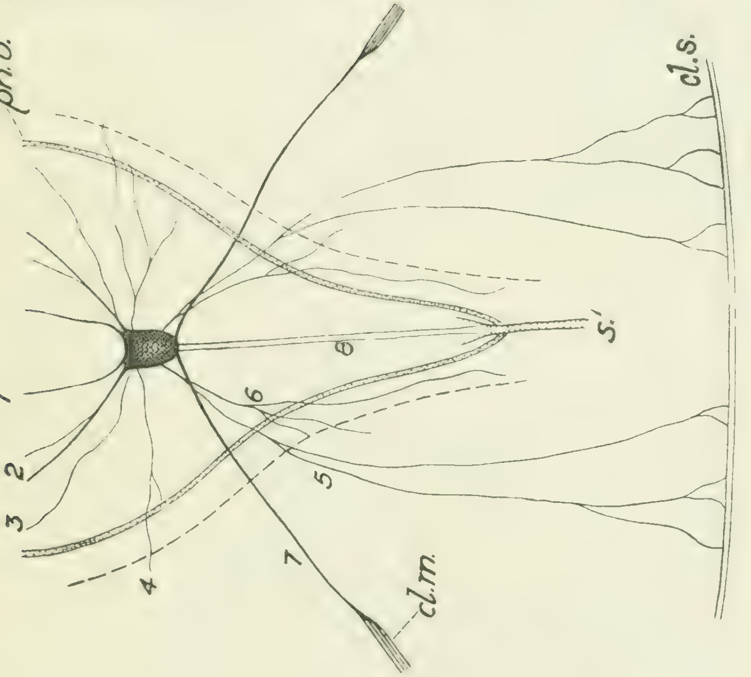
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Fig. 5.

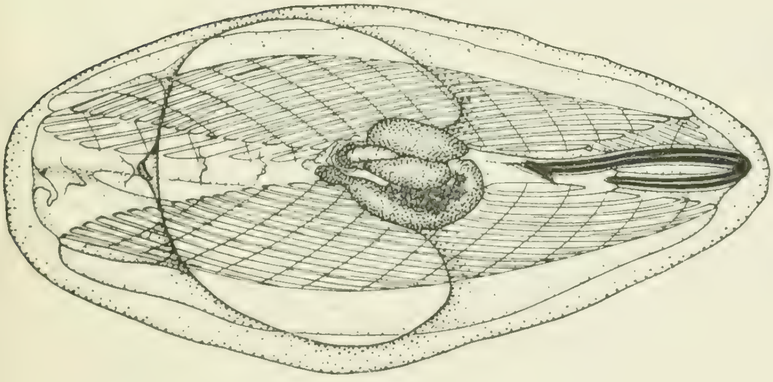

Fig. 4.

PYROSOMA AGASSIZI.

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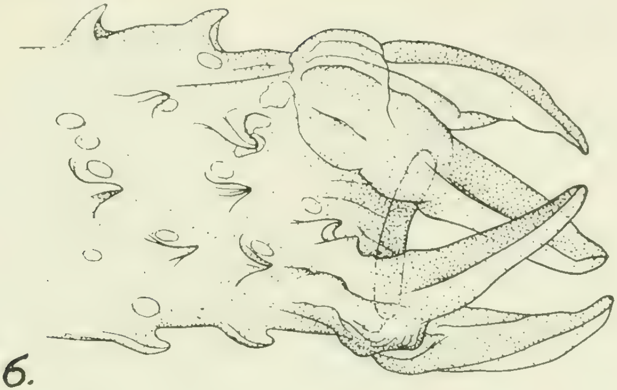

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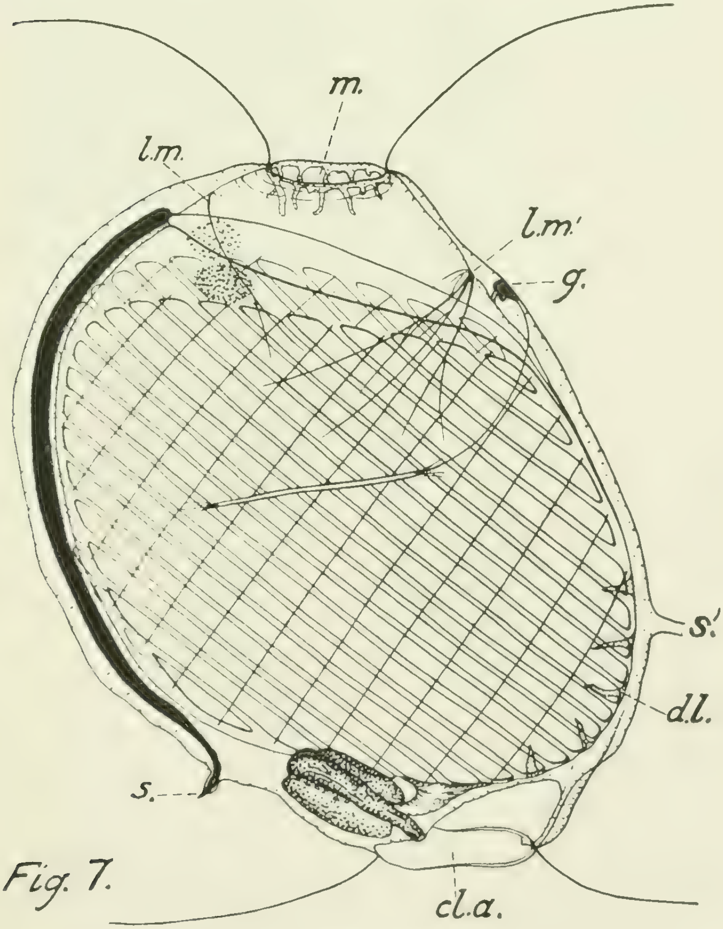
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Fig. 7.

PYROSOMA AGASSIZI.

FOR EXPLANATION OF PLATE SEE PAGE 270.

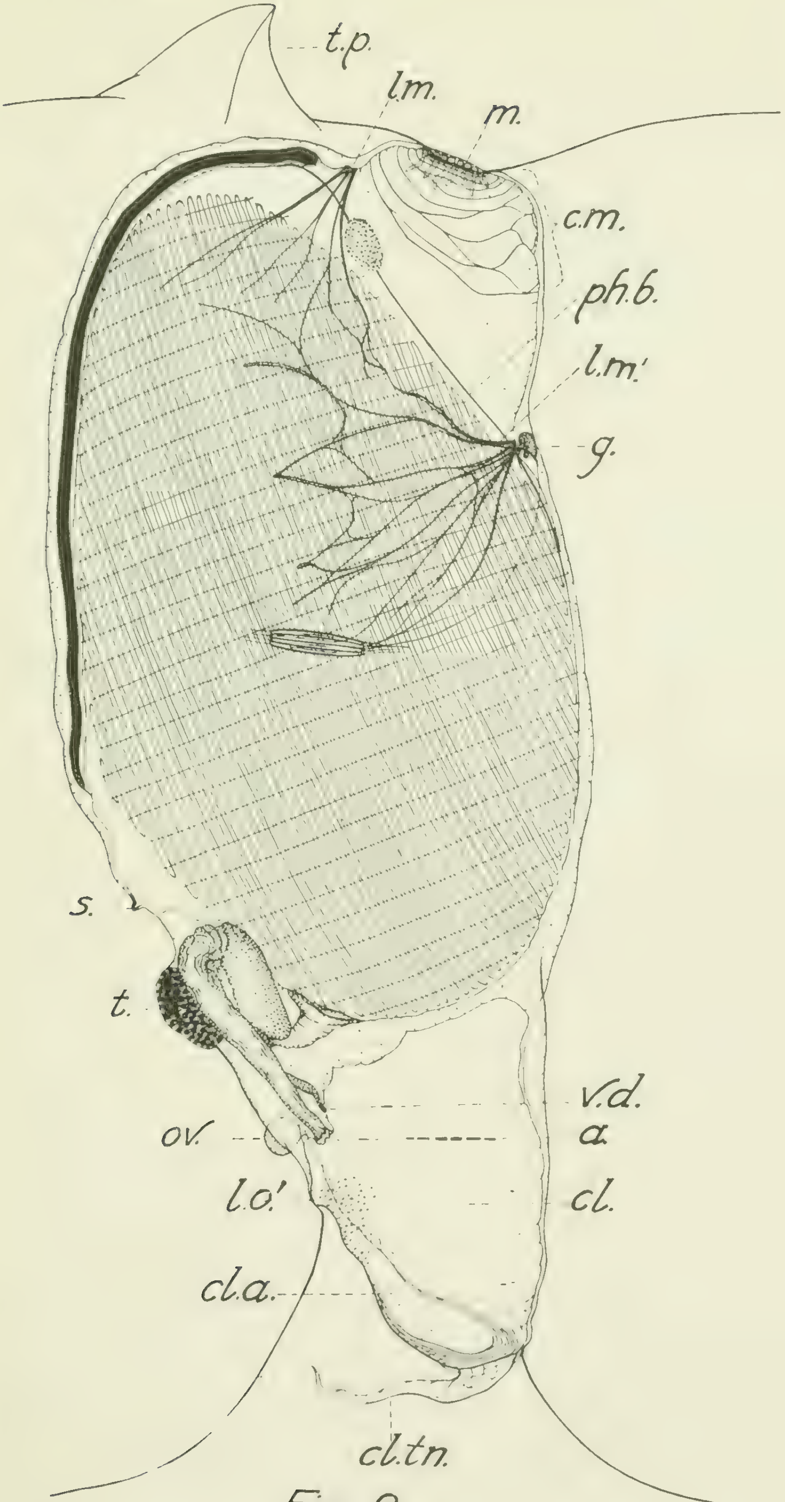
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Fig. 8.

PYROSOMA SPINOSUM.

FOR EXPLANATION OF PLATE SEE PAGE 270.

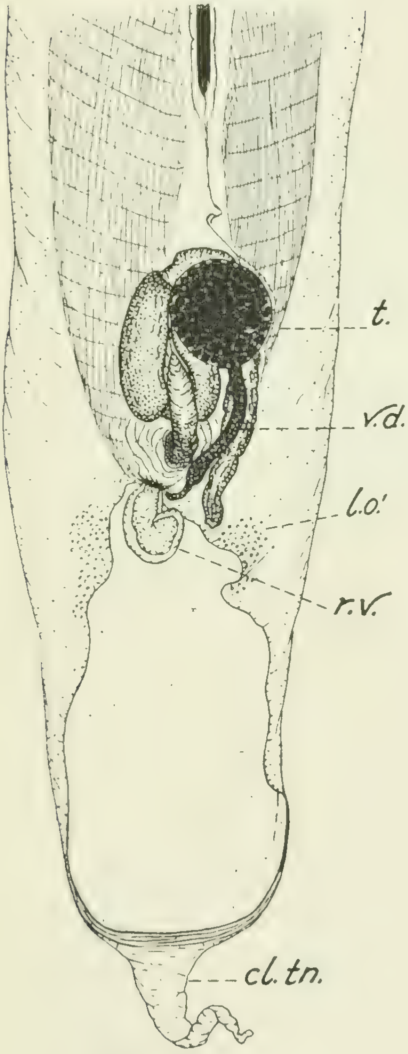
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Fig. 9.

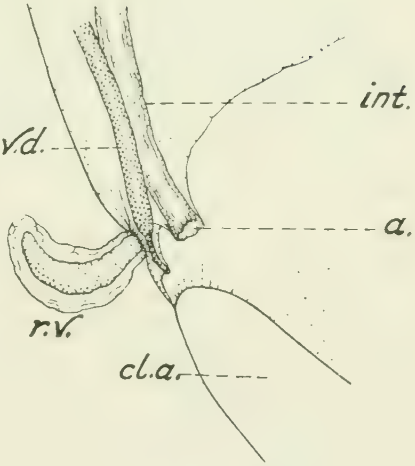
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Fig. 10.

PYROSOMA SPINOSUM.

FOR EXPLANATION OF PLATE SEE PAGE 270

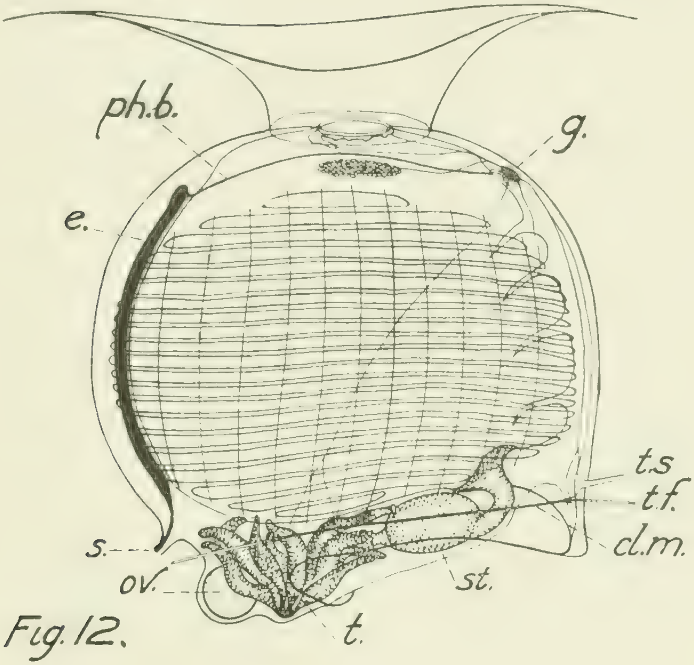
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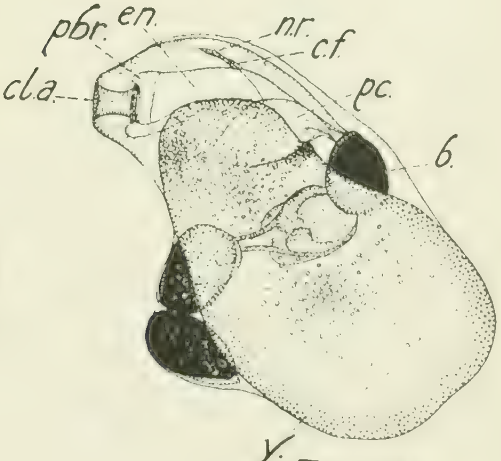
Fig. 12.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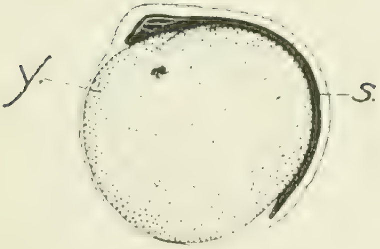

Fig. 11, A.

Fig. 11, B.

Pyrosoma spinosum (Figs. 11, A and B) and P. verticillatum (Fig. 12).

For explanation of plate see page 270.

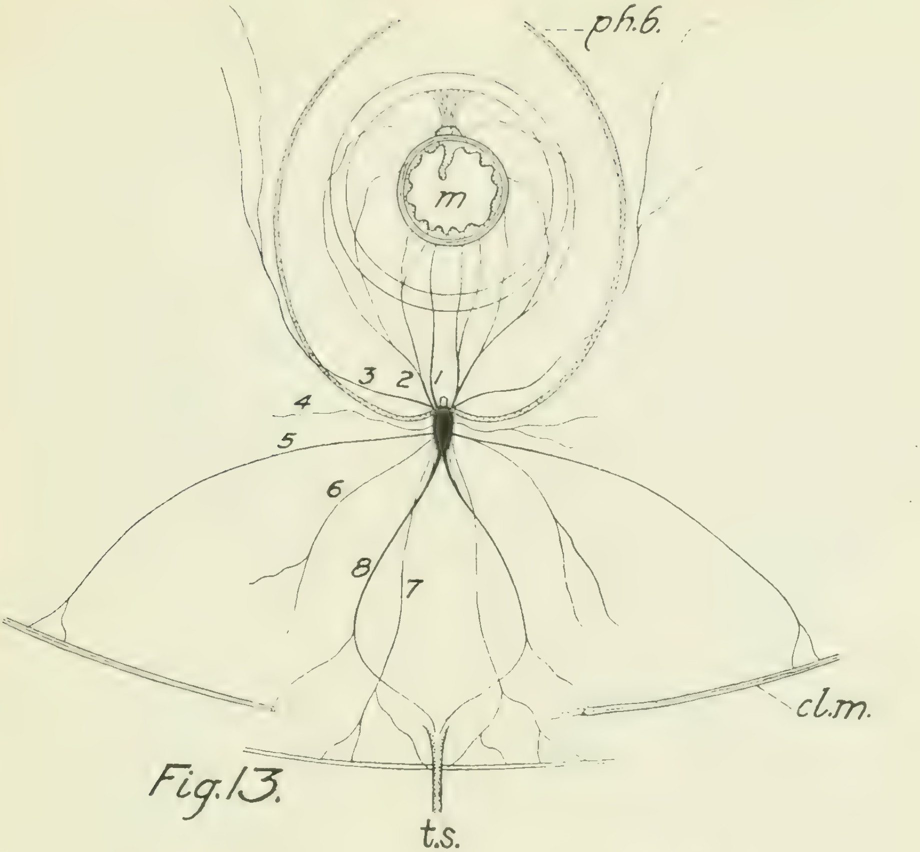
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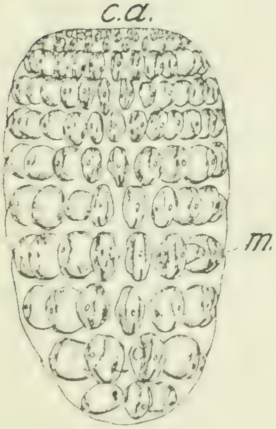
Fig. 13.



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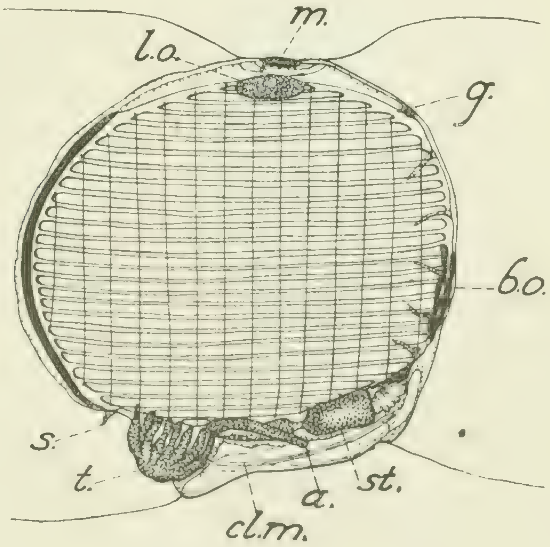
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Fig. 15.

PYROSOMA VERTICILLATUM (FIG. 13) AND ITS SUBSPECIES CYLINDRICUM (FIGS. 14, 15).

FOR EXPLANATION OF PLATE SEE PAGE 270.

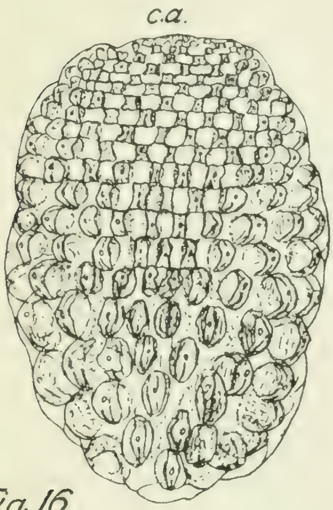

Fig. 16.

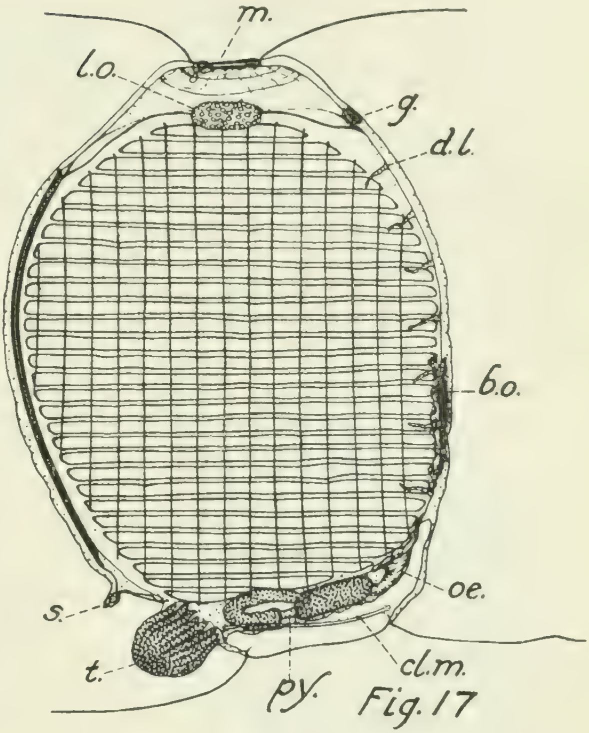
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Fig. 17

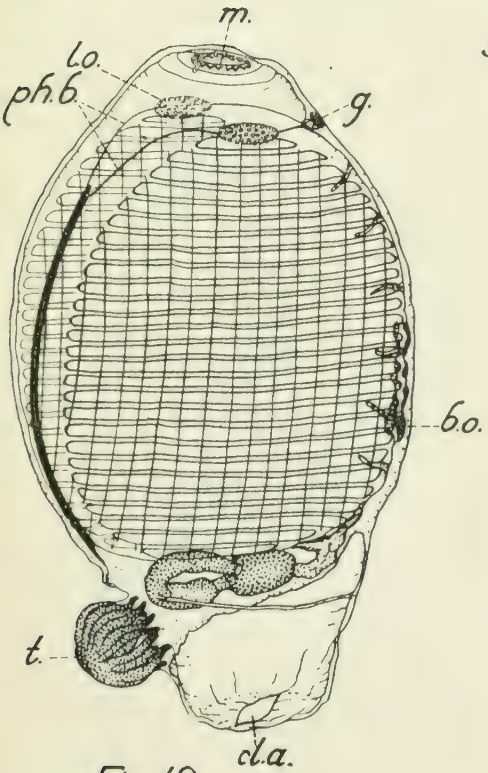
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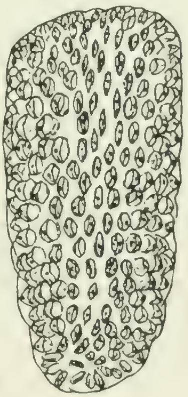
Fig. 18



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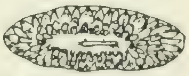
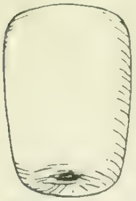


Fig. 20.

PYROSOMA HYBRIDUM (FIGS. 16, 17) AND P. ELLIPTICUM (FIGS. 18-20).

FOR EXPLANATION OF PLATE SEE PAGE 270.



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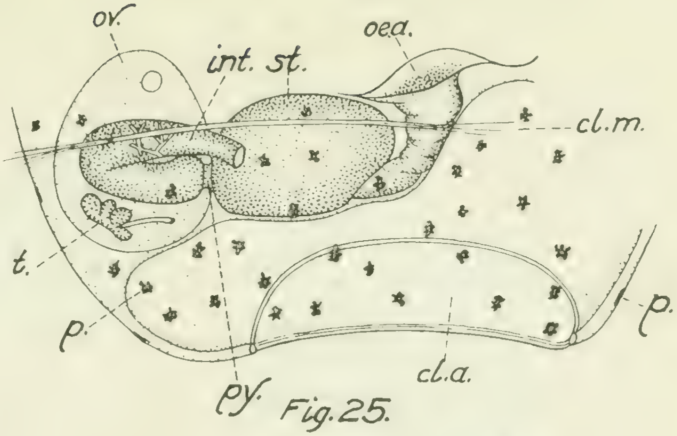
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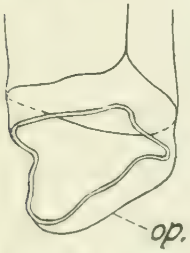
Fig. 25.



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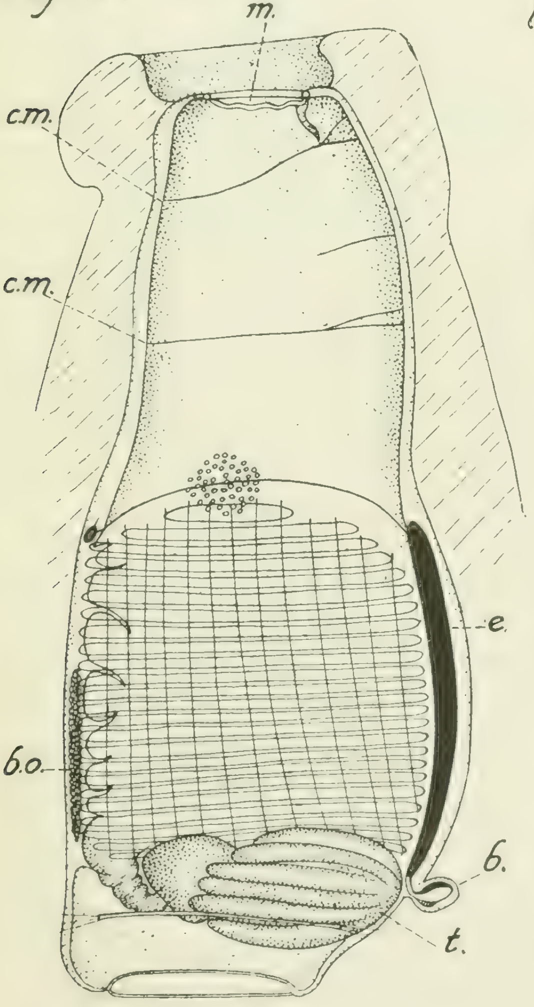
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Fig. 24.

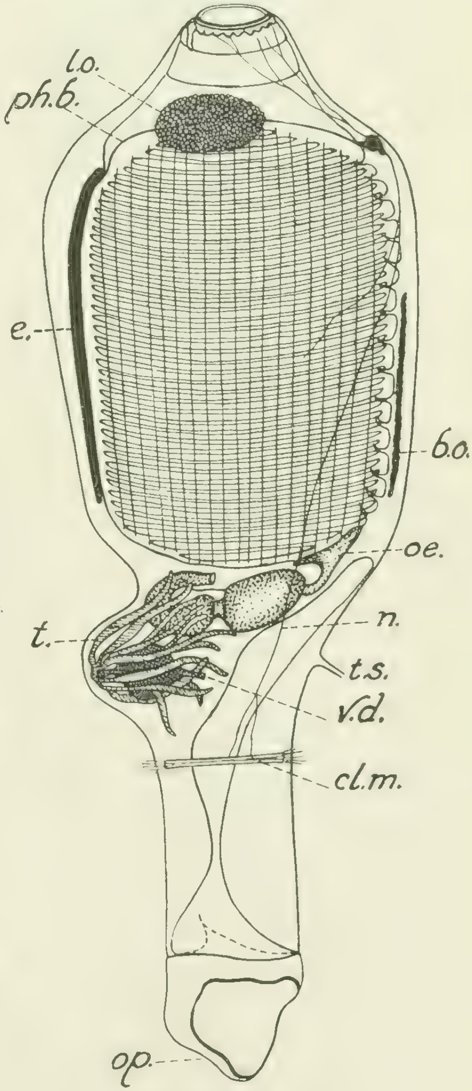
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Fig. 22.

PYROSOMA OPERCULATUM (FIGS. 21-23) AND P. AHERNIOSUM (FIGS. 24 AND 25).

FOR EXPLANATION OF PLATE SEE PAGE 271.

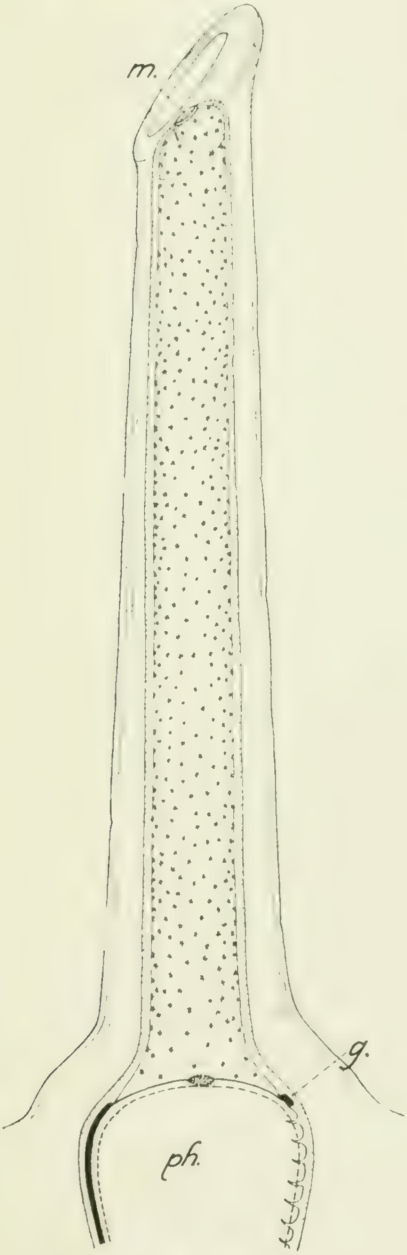

Fig. 26.

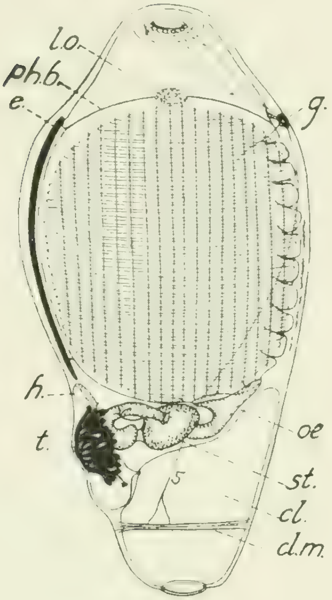
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Fig. 27.

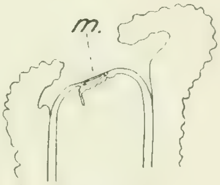

Fig. 28.

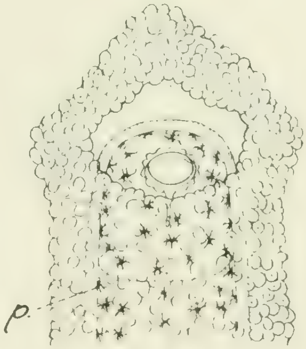

Fig. 29.

PYROSOMA OVATUM.

FOR EXPLANATION OF PLATE SEE PAGE 271.

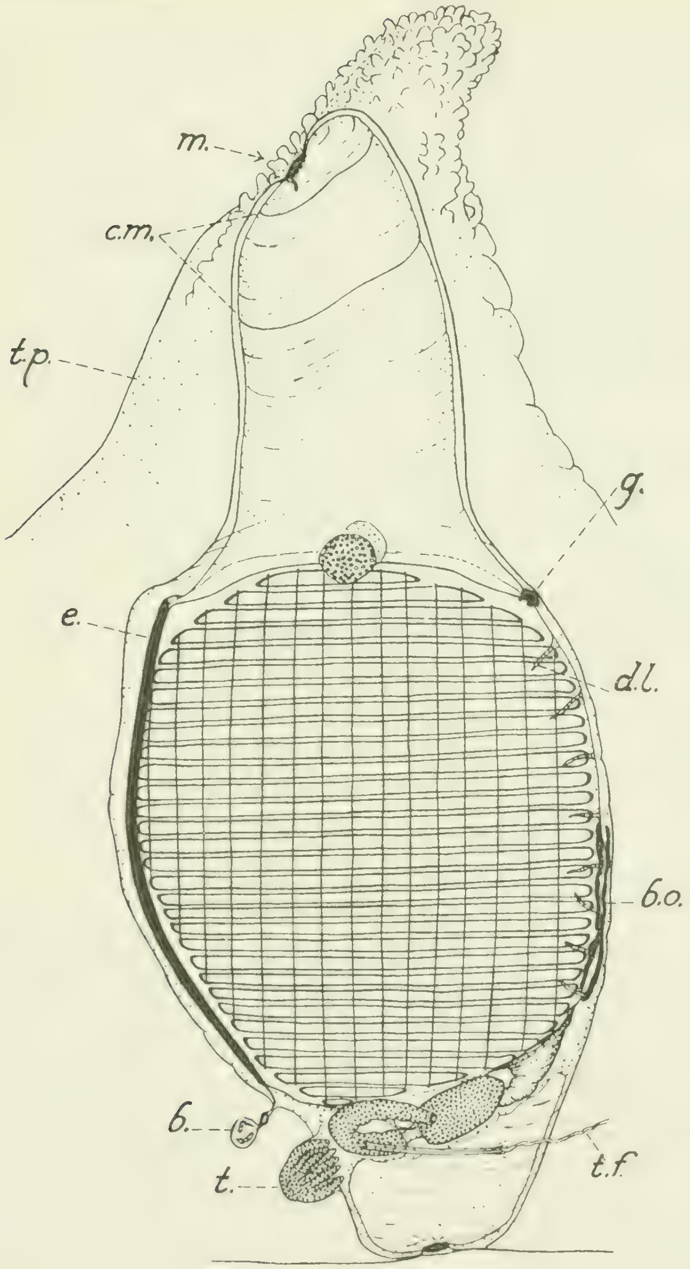
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Fig. 30.

PYROSOMA ATLANTICUM ATLANTICUM.

For explanation of plate see page 271.

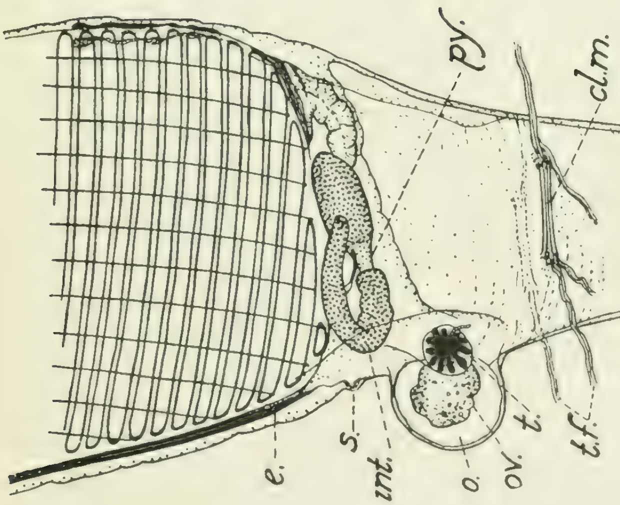
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Fig. 31

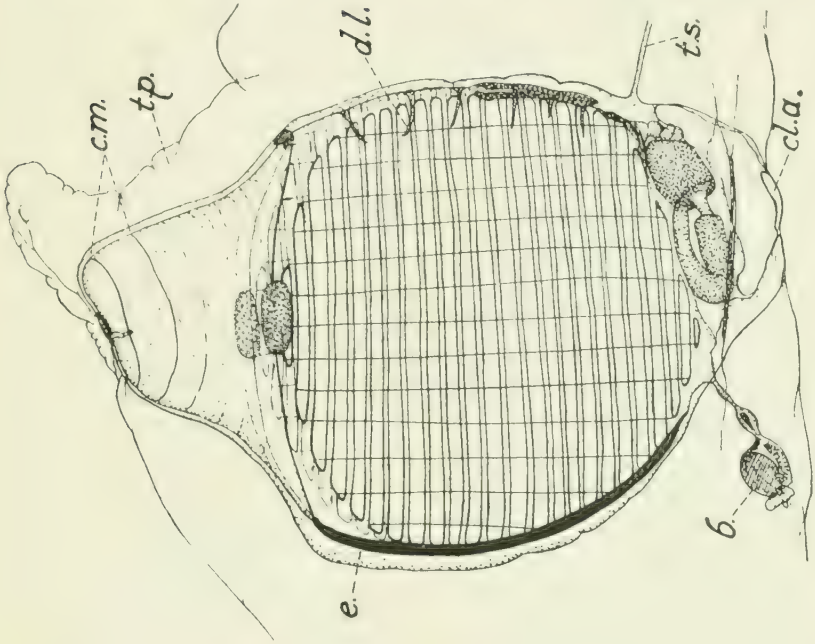
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Fig. 32.

PYROSOMA ATLANTICUM ATLANTICUM.

FOR EXPLANATION OF PLATE SEE PAGE 271

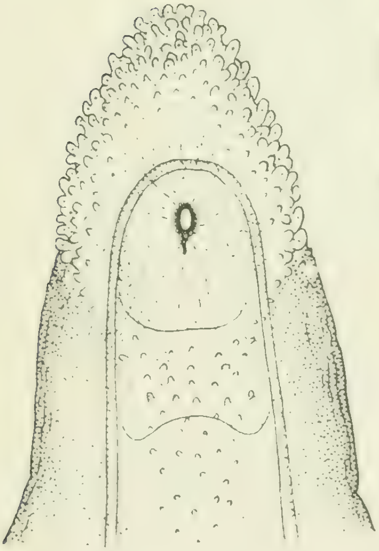

Fig. 33.

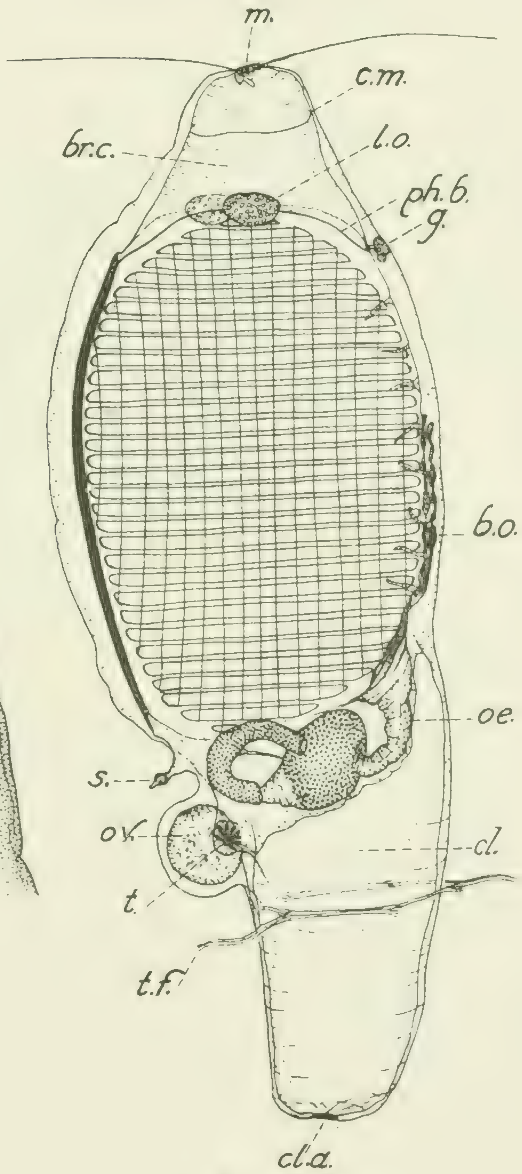
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Fig. 34.

PYROSOMA ATLANTICUM ATLANTICUM (FIG. 33) AND P. ATLANTICUM HAWAIIENSE (FIG. 34).

FOR EXPLANATION OF PLATE SEE PAGE 271.

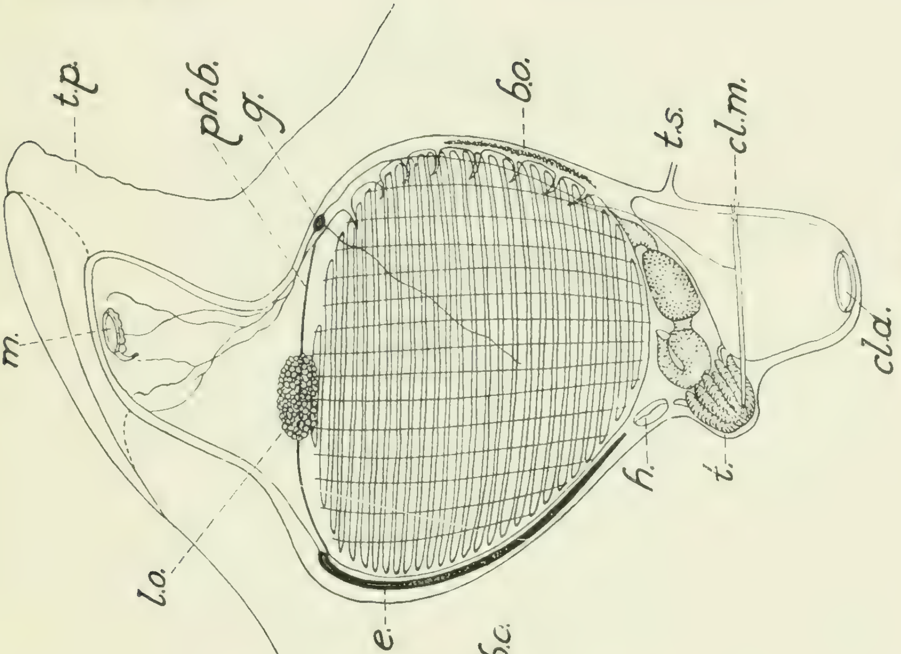
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Fig. 36.

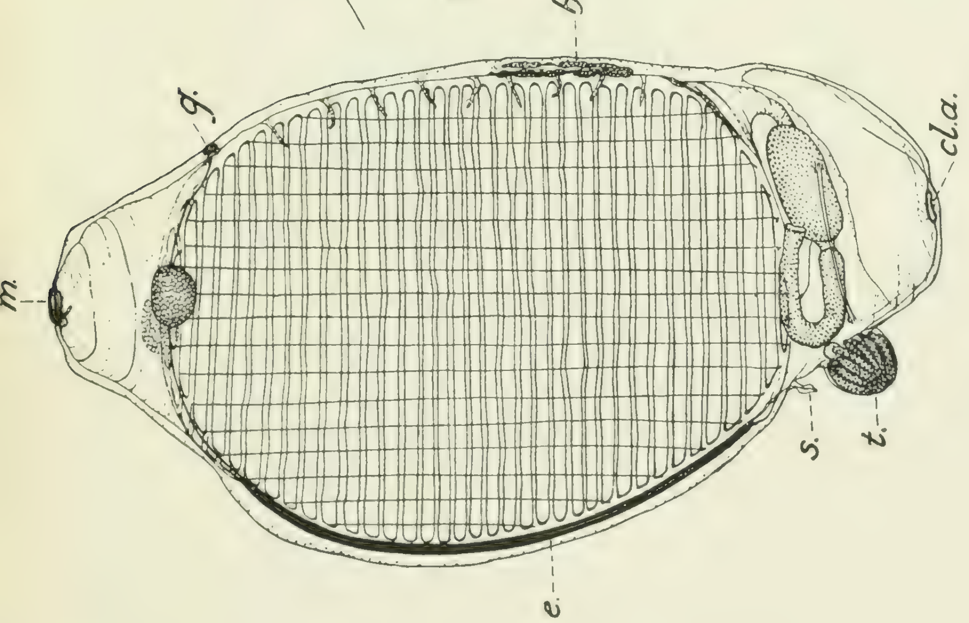
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Fig. 35.

PYROSOMA ATLANTICUM PARADOXUM (FIG. 35) AND P. ATLANTICUM TRIANGULUM (FIG. 36).

FOR EXPLANATION OF PLATE SEE PAGE 271.

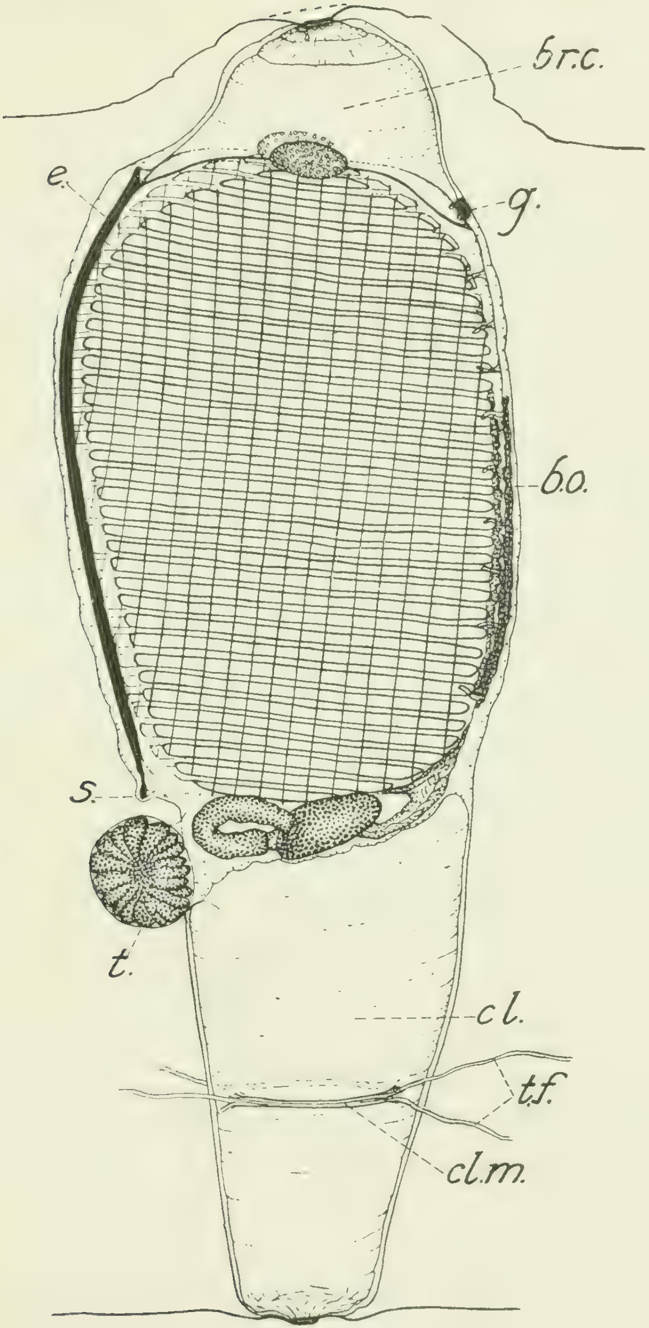
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Fig. 37.

PYROSOMA ATLANTICUM GIGANTEUM.

FOR EXPLANATION OF PLATE SEE PAGE 271

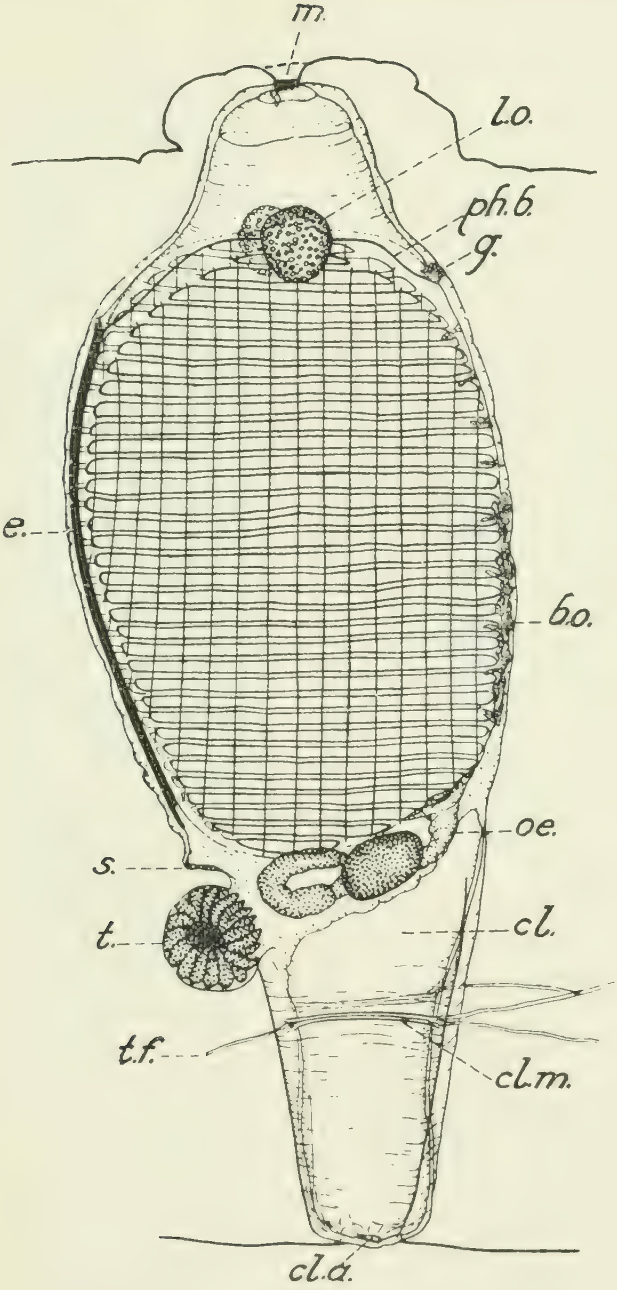
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Fig. 38.

PYROSOMA ATLANTICUM ECHINATUM.

FOR EXPLANATION OF PLATE SEE PAGE 271.

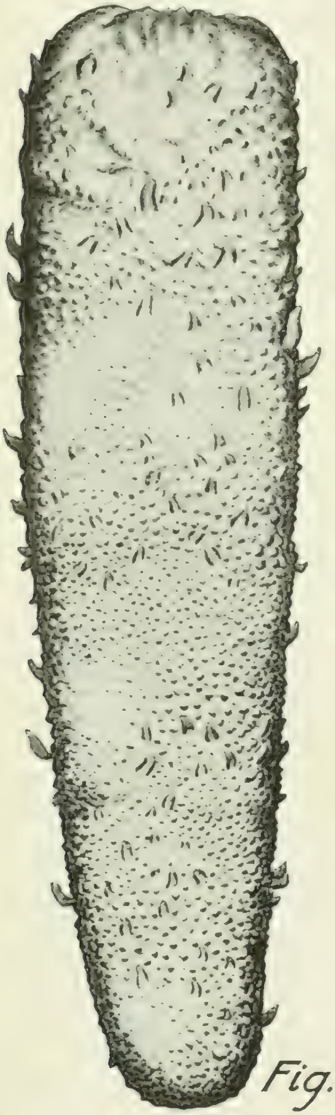

Fig. 39

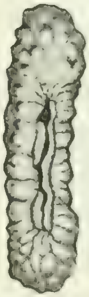

Fig. 40

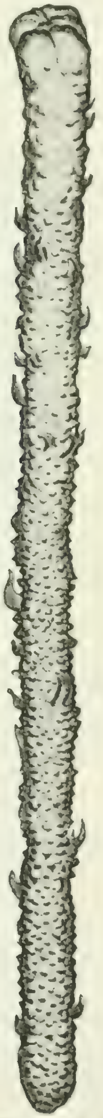

Fig. 41

PYROSOMA ATLANTICUM, FORM DIPLEUROSOMA.

FOR EXPLANATION OF PLATE SEE PAGE 272.

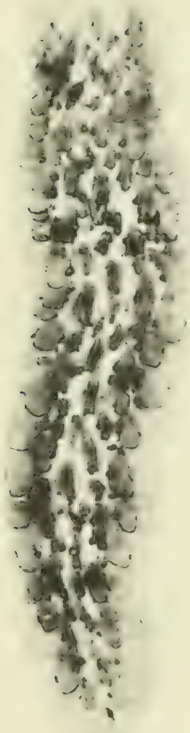

Fig. 42

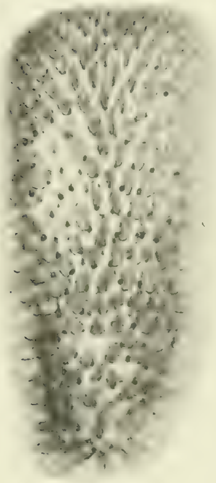

Fig. 44

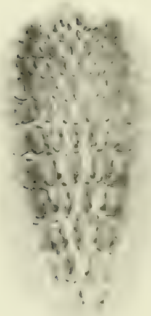

Fig. 43

PYROSOMA AGASSIZI (FIG. 42); P. VERTICILLATUM CYLINDRICUM (FIG. 43); P. ELLIPTICUM (FIG. 44).

FOR EXPLANATION OF PLATE SEE PAGE 272.

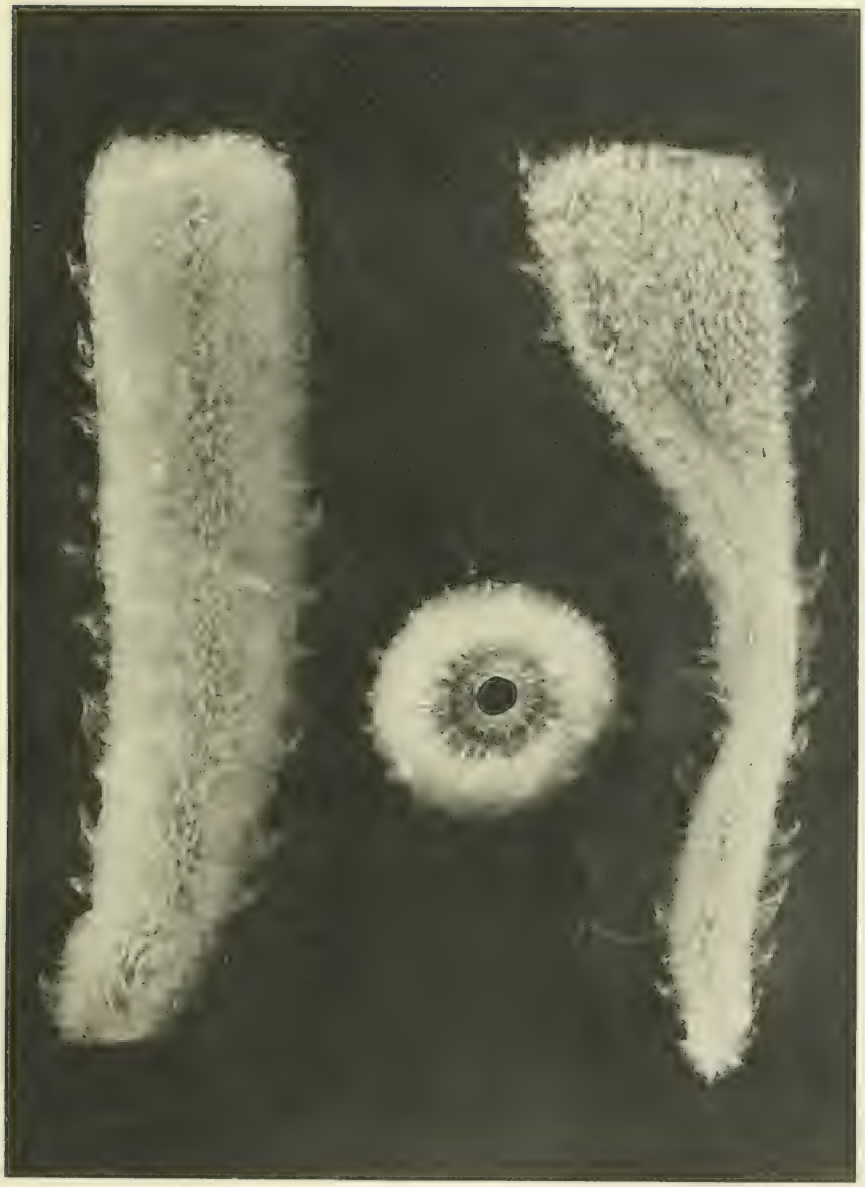

Fig. 45 *Fig. 46* *Fig. 47*

PYROSOMA ATLANTICUM ATLANTICUM (FIGS. 45 AND 46); P. ATLANTICUM FORM DIPLEUROSOMA (FIG. 47).

FOR EXPLANATION OF PLATE SEE PAGE 272.

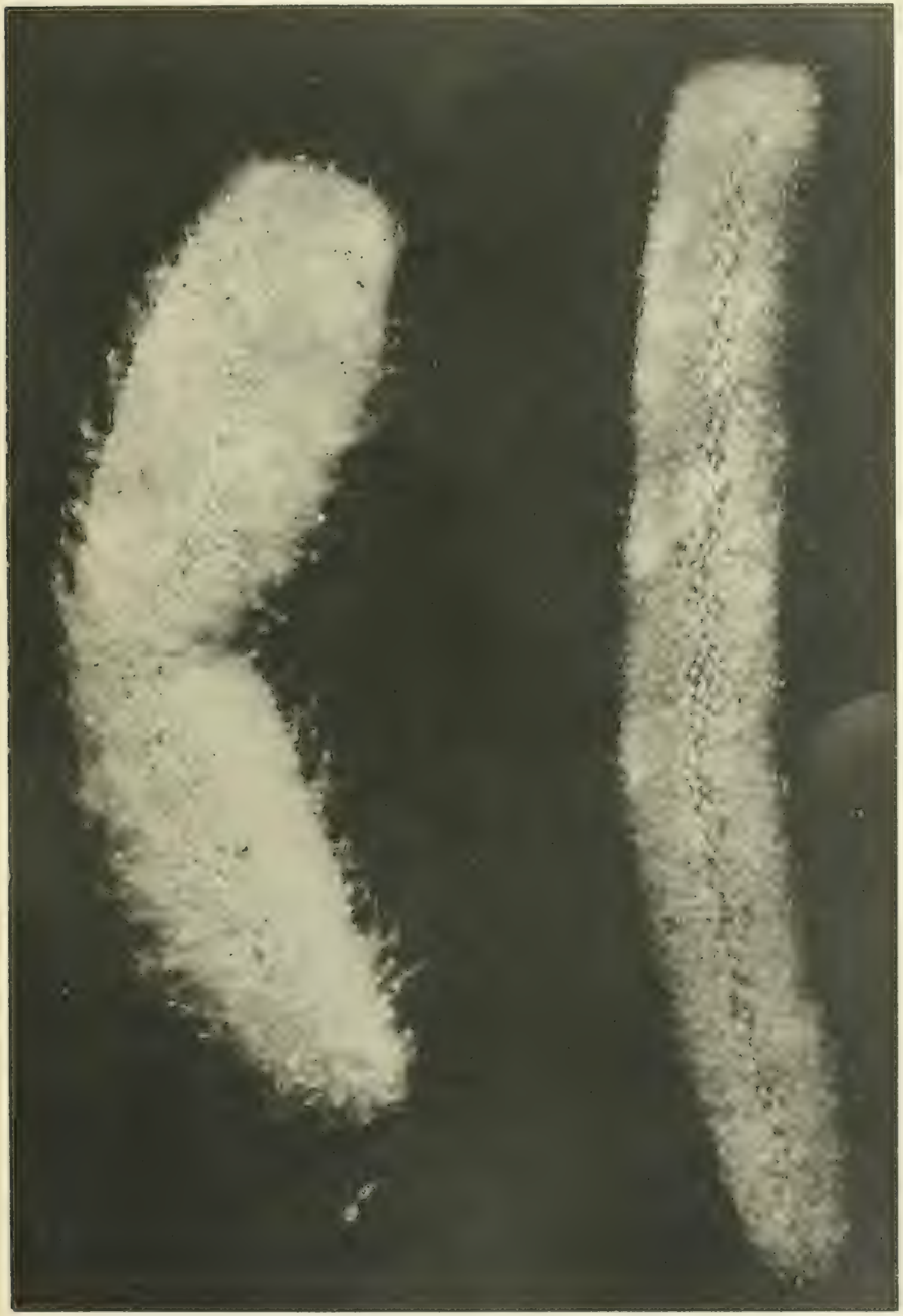

Fig. 48 *Fig. 49*

PYROSOMA ATLANTICUM ECHINATUM (FIG. 48); P. ATLANTICUM HAWAIIENSE (FIG. 49).

FOR EXPLANATION OF PLATE SEE PAGE 272.

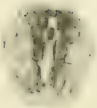

Fig. 50

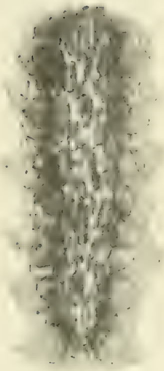

Fig. 53

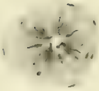

Fig. 51

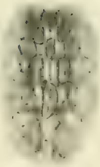

Fig. 52

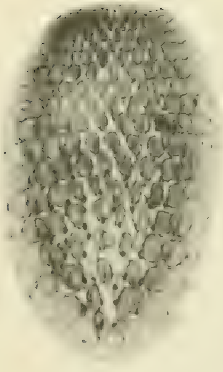

Fig. 54

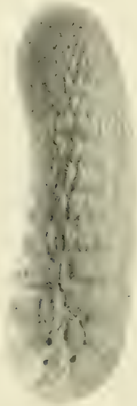

Fig. 55

PYROSOMA ATLANTICUM, SUBSPECIES DOUBTFUL (FIGS. 50 AND 52); P. ATLANTICUM ATLANTICUM (FIG. 53); P. HYBRIDUM (FIGS. 54 AND 55).

FOR EXPLANATION OF PLATE SEE PAGE 272.

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SILICIOUS AND HORNY SPONGES COLLECTED BY THE U. S. FISHERIES STEAMER "ALBATROSS" DURING THE PHILIPPINE EXPEDITION, 1907-1910

By H. V. Wilson

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INTRODUCTION

The collection of Philippine sponges included only a few Calcarea. These are reserved for separate study. The Hexactinellids were placed in the hands of the late Professor I. Ijima, of the University of Tokio.

The following report, it is hoped, will prove useful to zoologists entering upon the work of classification, as something of a guide to the contemporary taxonomy of sponges, more especially of the tetraxonid sponges, and to the literature dealing with this subject. It may be taken, at the date of writing, as an index to the families and genera of the Astrophora, Hadromerina, Sigmatophora, to the subfamilies of the Halichondrina, and to the families and genera of the Lithistida. In places I have gone more into detail, attempting for instance to list the species of Sigmatophora and Lithistida that have been established since 1903 (the date of the Tierreich synopsis, Lendenfeld, 1903). Doubtless there are omissions.

The phenomena that are roughly grouped under the head of variation force themselves upon the attention of all who undertake to classify sponges. As in former papers (especially 1904) I record, throughout the body of the report, considerable data that come under this head. Such data I am aware can not in themselves lead to any definite conclusions concerning the causes of change—namely, conditions under which changes appear. But they do add to our knowledge of the kinds of variations that occur. They contribute to what we may call the classification of variation phenomena, without a knowledge of which experimental work on the production of new races and the improvement or even the safeguarding of old ones can scarcely go far.

Variation phenomena in a group of such plastic organisms as sponges become involved, perhaps more directly than in many other groups, in the practical work of classification—that is, the setting up of categories or the assigning of bodies to categories already in use. As I point out under *Donatia* and *Tetilla*, it is only by arbitrarily disregarding variation that we can rigidly adhere to a mode of classification which splits genera into subgenera and species into subspecies, with the tacit understanding that there must be a subgroup into which each individual organism will fit. However foreign such a mode of classification is in the abstract to our ideas on the evolution of organisms, it is clear that in the actual work of classification it has to-day a considerable influence.

As to technical methods I can refer those who are not already familiar with such to a previous statement (Wilson, 1902, p. 378). I may add that for sections celloidin imbedding proves very convenient. Surface preparations of dermal and cloacal membranes are desirable. For boiling out spicules many prefer nitric acid to caustic potash. In the study of lithistid desmas the nitric acid is to be followed by hydrofluoric acid (Sollas 1888, p. CLXV). I may add that the crepis of the desma is sometimes more distinct in water than in balsam; I have also used to advantage pure glycerine and, again, cedar oil.

The customary methods are employed with respect to spicule measurements—that is, the aim is always to give an idea as to the characteristic size, namely, the common average, young forms and extremes being excluded. For this purpose sometimes the dimensions of selected representative spicules are given; sometimes an average is given covering a number of spicules of commonly occurring sizes. More often, perhaps, the common range of size, common minimum to common maximum, is given. With this understanding the qualifying word "about" has been usually omitted.

There is a minor linguistic matter in which English-writing zoologists should, it seems to me, reach an agreement. I refer to the formation of plurals in the case of words like desma, dragma, sigma, toxa (some of the dictionaries give toxon, but it is the made-over form, toxa, that has come into actual use in the literature, following Sollas, not the Greek singular), oxea, chela, etc. We use such words in the singular as English words and there is no valid linguistic reason for not following Sollas' example (1888, p. LIX) in using the "s" plural. Where the word has preserved its Latin form (as chela) we especially shrink from this plural, but I realize that if the terms are to be used freely by many, as should be the case, we must use them as English words and as we now say museums, so must we learn to say aquariums and chelas. In this reform spirit I have gone over my text and endeavored to bring it throughout into conformity with Sollas' principle. The singular forms clad, rhabd, which demand the "s" plural, are used instead of the Latin forms, cladus, rhabdus, etc.

Dendy[1] (1921, p. 101) takes particular exception to the use of oxea in the singular as "erroneous" and would use oxeon, plural oxea. But oxea in the singular is now a well-recognized word, classified as modern Latin by the dictionaries, having arisen as a viable form through Professor Sollas' operation on the Greek adjective. Oxeon would seem to be a word of contemporary coinage and unnecessary. The adjective should then be oxeate and not oxeote.

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[1] The death of this eminent investigator, to whom we owe so much, was announced while this paper was passing through the press.

For the precise location and characteristics of the stations at which sponges were taken I refer to United States Bureau of Fisheries Document No. 741 (Dredging and Hydrographic Records of the U. S. Fisheries Steamer *Albatross* during the Philippine Expedition, 1907–1910, Washington, 1910).

An outline of the classification followed in this report is here given:

Class Noncalcarea Vosmaer, 1887.

Order 1. Myxospongida Dendy, 1905 (Myxospongiae part Lendenfeld, 1885, history of term here reviewed; Myxospongiae Sollas, 1888, p. XCVIII).—Simple forms without a skeleton. Absence of skeleton primitive. The genera are *Halisarca* Dujardin, 1838, *Oscarella* Vosmaer, 1887, *Bajulus* Lendenfeld, 1886, *Hexadella* Topsent, 1896. With regard to the position of these sponges there is marked disagreement. Lendenfeld, 1889, 1894*c*, looks on *Halisarca* and *Bajulus* as degenerate derivatives of *Darwinella* and assigns them to his Hexaceratina (in the Triaxonia), to which group Topsent, 1896*b*, also assigns *Hexadella*. *Oscarella* is separated by Lendenfeld, 1889, 1903, 1906, from the other genera of the group, as here understood, and transferred as a family (Oscarellidae) to the Homosclerophora (Microsclerophora). Hentschel, 1909, 1912, follows the same practice and further combines *Hexadella* with *Oscarella*.

Order 2. Hexactinellida O. Schmidt, 1870 (Triaxonia, F. E. Schulze, 1887).—With triaxonid (characteristically hexactinellid) siliceous spicules.

Order 3. Tetraxonida Dendy, 1905 (Demospongiae Sollas, 1888, minus Ceratosa).—The characteristic form of spicule is a siliceous four-rayed sclerite, each ray representing a particular axis (tetraxonid or tetractinellid spicule). But in some groups these spicules have been lost.

Suborder 1. Homosclerophora Dendy, 1905. (Microsclerophora Sollas, 1888; Microsclerophora part Lendenfeld 1889).

Family 1. Plakinidae F. E. Schulze, 1880.—The genera are *Plakina* F. E. Schulze, 1880; *Plakortis* F. E. Schulze, 1880; *Plakinastrella* F. E. Schulze, 1880 (assigned by Sollas, 1888, to Theneidae, by Dendy, 1905, to Pachastrellidae); *Dercitopis* Dendy, 1905.

Family 2. Corticidae Vosmaer, 1887, Sollas, 1888.—Lendenfeld, 1903, deletes the family. The genera are *Corticium* O. Schmidt, 1862 (assigned by Lendenfeld, 1903, to the Plakinidae); *Calcabrina*, Sollas, 1888 (synonymous with *Stoeba* Sollas, 1888, according to

Dendy, 1905); *Corticella* Sollas, 1888 (merged by Lendenfeld, 1903, in *Calthropella* Sollas, 1888); *Rhacella* Sollas, 1888 (merged by Lendenfeld, 1903, in *Plakina*).

Family 3. Thrombidae. The only genus is *Thrombus* Sollas, 1888. Lendenfeld, 1903, transfers the genus to the Plakinidae, deleting Thrombidae.

(For the definitions and contents of the remaining groups which are given by name below, see the text.)

Suborder 2. Astrophora Sollas, 1888.

Suborder 3. Hadromerina Topsent, 1898. (Hadromerina Topsent, 1898*c*, plus Chondrosidae; Pseudotetraxonina Vosmaer, 1887, plus Clavulina Vosmaer, 1887, plus Oligosilicina part Vosmaer, 1887, plus; Clavulina Vosmaer, Ridley and Dendy, 1887, plus; Spintharophora Sollas, 1888, minus Axinellidae plus Epipolasidae Sollas, 1888, plus Placospongidae Sollas, 1888, plus; Astromonaxonellida Dendy, 1905.)

Suborder 4. Sigmatophora, Sollas, 1888.

Suborder 5. Halichondrina Vosmaer, 1887 (Halichondrina Authors, Sigmatomonaxonellida Dendy, 1905.)

Suborder 6. Lithistida O. Schmidt, 1870.

Order 4. Keratosa Grant, 1826, 1861.

A close linkage of the Astrophora and Hadromerina on the one hand, under the designation Astrotetraxonida (Hentschel, 1909), and of the Sigmatophora and Halichondrina on the other, under the designation Sigmatotetraxonida (Hentschel, 1911*a*), has come into extensive use in recent years (Dendy, Hentschel, and others; also the Zoological Record). It has not been, however, by any means universally adopted (see Topsent, Thiele), and I am now inclined to believe that it rests on too many assumptions. And yet it is generally recognized that many of the Hadromerina give indication of their descent from the Astrophora, the relationship between the two being fully as close as, if not closer than, that between the Astrophora and Sigmatophora. This makes somewhat artificial the maintenance of the older groups Tetractinellida, comprising the Astrophora and Sigmatophora, and Monaxonida, comprising the Hadromerina and Halichondrina, for we are very much in the dark as to the genetic relationship between the two latter subdivisions. Under these circumstances recourse may be had to the noncommittal method of arranging the subgroups (Astrophora, Hadromerina, Sigmatophora, Halichrondina) serially, and this to-day seems to me the best practice.

The collection is deposited in the United States National Museum.

Since the manuscript of this report was completed, several memoirs of importance have appeared, but the writer believes that the data in them, however valuable, do not necessitate changes in the views on classification here adopted.

SYSTEMATIC DESCRIPTION.

Order TETRAXONIDA.

Demospongiae SOLLAS, 1888, minus *Ceratosa*.
Tetraxonida DENDY, 1905.

The characteristic form of spicule is a silicious four-rayed sclerite, each ray representing a particular axis (tetraxonid or tetractinellid spicule). But in some groups these spicules have been lost.

Suborder ASTROPHORA.

Astrophora SOLLAS, 1888.

With tetraxonid megascleres and astrose microscleres; without desmas.

The families are: Theneidae, Stellettidae, and Geodiidae.

Family THENEIDAE.

Theneidae SOLLAS plus *Pachastrellidae* (Carter), SOLLAS, 1888.
Asterostreptidae TOPSENT, 1902*b*.
Stellettidae part plus *Pachastrellidae* LENDENFELD, 1903.
Theneidae plus *Pachastrellidae* LENDENFELD, 1906.
Pachastrellidae HERNANDEZ, 1914.

The characteristic astrose microscleres are streptasters; oxyasters occur also in some species. The ectosome does not form a cortex.

I follow Topsent in combining the Theneidae and Pachastrellidae, but it does not appear that the new name Asterostreptidae is necessary, unless the old groups are retained as subfamilies. But it seems clear that the genera can not at present be successfully thrown into groups. The family is therefore to be directly divided into genera. As to the choice of name for the combined group, *Thenea* Gray (1867) antedates *Pachastrella* Schmidt (1868).

In addition to the component genera recognized by Topsent, 1902*b* (*Thenea* Gray, *Sphinctrella* Schmidt, *Poecillastra* Sollas, *Pachastrella* Schmidt, *Nethea* Sollas, *Triptolemus* Sollas, *Characella* Sollas) are to be added *Chelotropaena* Lendenfeld (1906, p. 231), and *Yodomia* Lebwohl (1914, p. 63; Dendy, 1916, p. 232).

Other genera classed by some in the Theneidae or Pachastrellidae, but in actual fact (namely, without employing phylogenetic interpretation) excluded from the combined family as here defined, are:

Stoeba Sollas (1888, p. 102). Of uncertain position. Assigned by Sollas to the Theneidae, by Dendy (1905) to the Pachastrellidae; merged by Topsent (1902) and Lendenfeld (1903) in *Dercitus* Gray.

Dercitus Gray (1867, p. 542). Of uncertain position. Assigned by Sollas (1888), Lendenfeld (1903), Hentschel (1909), and Lebwohl (1914) to the Pachastrellidae; by Topsent (1902) to the Stellettidae.

Ancorella Lendenfeld (1906, p. 247).

Pacamphilla Lendenfeld (1906, p. 251). (See Hentschel, 1912, p. 308.)

Calthropella Sollas (1888, p. 107). Assigned to Pachastrellidae by Sollas and by Lendenfeld (1903); by Topsent (1902) to Stellettidae and merged in *Corticella* Sollas; by Lendenfeld (1906, p. 301) to his new family Calthropellidae, a family of doubtful value, which I prefer not to use. Genus, I believe, is best assigned to the Stellettidae.

Chelotropella Lendenfeld (1906, p. 302). Likewise best assigned to the Stellettidae, if, indeed, the genus is to be used.

Pachastrissa Lendenfeld (1903, p. 80). Genus of doubtful value.

Scutastra Hernandez (1912, p. 12; 1914, p. 8). Assignable to Geodiidae.

Genus THENEA Gray (1867).

Thenea Gray, 1867, p. 541.

Of more or less symmetrical shape; with one or more conspicuous oscula and with specialized lateral pore areas in addition to scattered pores. With rootlets. The characteristic megascleres are dichotriaenes, arranged with other megascleres (triaene forms and oxeas) radially.

THENEA GRAYI Sollas.

Plate 45, figs. 1 and 2.

Thenea grayi Sollas, 1888, p. 65.

Three small specimens, one each from stations 5127, 5424, and 5425, are referable to this species, and indeed to the typical form *T. grayi grayi* (Lendenfeld, 1903). They range in diameter from 12 to 15 mm. As in Sollas' type (1888, p. 65, pl. 6, figs. 21, 22), the upper surface is flattened and without an osculum. The under surface is rounded or somewhat conical and bears several bundles of root spicules, the longest 20 mm. in length. As in the type there are two large, lateral, depressed, fringed aquiferous areas opposite one another; the fringes much longer along the upper margin, projecting here 10–13 mm. The upper surface of the sponge is more or less hirsute with spicules that project about 2 mm.

Sollas interprets one of the aquiferous areas as oscular, the other as inhalent. This interpretation is supported by my specimens, in which there is a constant anatomical difference between the two areas. Both are shallow, cloacalike spaces into which open numerous canals. But whereas the exhalent space is covered in with a coarsely fenestrated membrane the inhalent space is covered in with a much finer fenestrated membrane, the apertures in the latter ranging from about 150 to 250 μ in diameter. Nevertheless, the inhalent membrane may include a few larger apertures, which seem to be natural. It is a curious fact that directly in the center of the inhalent membrane there opens a canal coming from the interior of the sponge and quite unconnected with the surrounding vestibular space, that is roofed over by the membrane. The areas are different again in that the inhalent one is in all specimens considerably larger than the exhalent. Both are circular or ellipsoidal in outline.

Spicules.—1. Dichotriaenes, abundant, clads overlapping: rhabdome 1,800–3,500 by 70 μ, protoclad 200 by 70 μ, deuteroclads 1,000–1,150 μ long.

2. Protriaenes; rhabdome reaches 4.5 mm. by 70 μ; clads 700 μ in length, strong, curving.

3. Oxeas. In the fringes the spicules are of the length of the fringe and about 35 μ thick.

Similar slender oxeas, about 4 mm. long, often but not always accompanying the rhabdomes of the triaenes; also projecting generally from the surface, along with smaller ones down to 700 μ long. Stouter oxeas, usually somewhat curved, occur in interior, 4.5 mm. by 70 μ.

4. Anatriaenes. In the spicules of the body, clads 35–60 μ long, rhabdome long and slender.

Roots chiefly made up of very long, slender anatriaenes, with some oxeas. Clads of anatriaenes reach length of 0.5 mm., with a basal thickness about equal to that of rhabdome, 8–10 μ. Such anatriaenes were only seen near the ends of long roots; probably no such roots have been preserved in specimens of this species hitherto recorded.

5. Streptasters.

Plesiasters (pl. 45, fig. 1), very abundant throughout sponge, with 4 rays, ray length 80–140 μ.

Metasters (pl. 45, fig. 2, *a*, *b*), also very abundant throughout sponge; axis very short and curved, with 5–7 rays, ray length 20–36 μ.

Spirasters (pl. 45, fig. 2, *c*), total length 24–36 μ, ray length 10–16 μ; rays about 9–12 in number. Very abundant in the fenestrated membranes of the aquiferous areas; much less abundant in the general ectosome.

All three classes of streptasters grade into one another. But the intergrades are not numerous. The metasters, so designated by Sollas, have so small a number of rays that they differ only slightly, except in size, from the plesiasters.

Sollas' specimens (1888) came from Australian waters. Thiele (1898) records the type and eight subspecies from Japan. Lebwohl (1914) also records the type from Japan.

THENEA GRAYI, var. SULCATA, new variety.

A small specimen from station 5178, about 10 mm. in diameter, differs from the above in several points.

The upper surface is smooth and not hirsute, showing plainly under a lens the scattered pores. The under surface is well plastered with sand grains, etc.

The cloacal space is not covered in with a fenestrated membrane but is quite open; in other respects like that of the type. The inhalent area is expanded horizontally to such a degree that it extends more than halfway round the sponge in the shape of a long groove, much as in a specimen of *Thenea muricata* figured by Vosmaer (1882, pl. 1, fig. 1), or as in *T. pendula* Lendenfeld (1906, p. 210, pl. 22, figs. 11, 12.) The inhalent membrane is also more finely fenestrated than in the specimens of the type, the apertures ranging from 75 to 150 μ in diameter.

Several of the skeletal elements are smaller than those of the type. Thus in the 4-rayed plesiaster the common length of ray is only about 50 μ. In the metaster, with 6–7 rays, the common ray length is 16–20 μ. The dichotriaenes in the fragment examined had short deuteroclads, varying in length from 260 to 700 μ.

Genus SPHINCTRELLA Schmidt (1870).

Sphinctrella SCHMIDT, 1870, p. 65.

Massive, or lamellar, or sometimes incrusting forms. Without specialized pore areas. With one or many cloacal depressions fringed with long oxeas, into which numerous efferent canals open; cloaca may or may not be uniformly lined with a fenestrated membrane. Radially arranged triaenes are typically present over the whole or a part of the surface, but these may be absent. Similar triaenes, or the calthrops form, usually occur in the interior. Small oxeas (microxeas), varying considerably in size, represented sometimes by microtriads and microcalthrops, are scattered through the body.

SPHINCTRELLA BIFACIALIS, new species.

Plate 37, fig. 1; plate 45, figs. 4, 6.

Station D5543, one specimen.

Sponge massive, somewhat flattened from above downward; attached on the side to a coralline mass. The horizontal outline is roughly triangular; horizontal diameter 80 to 90 mm.; greatest vertical diameter 45 mm. One surface, doubtless the upper, bears a large cloacal depression about 10 mm. deep with an aperture 35 by 12 mm. The remaining surface represents the latero-inferior surface of the sponge.

The upper surface is thickly covered with projecting megascleres, protruding 2–3 mm. These prove to be long slender oxeas with a few of the large skeletal oxeas intermingled. Round the margin of the cloacal aperture (pl. 45, fig. 4, *c. m.*) these spicules, here somewhat longer, are inclined obliquely to the upper surface and radiate toward the center of the aperture, constituting a cloacal fringe. Much of the fringe has been destroyed, but in places it projects 4–5 mm.

The outer margin (pl. 45, fig. 4, *o. m.*) of the upper surface is a sharp edge which distinctly separates this surface from the latero-inferior surface of the sponge. At this edge the protruding spicules of the upper surface project radially outward and are longer than elsewhere, projecting in places 5–6 mm., constituting a marginal fringe which has been in large part destroyed.

The latero-inferior surface (pl. 45, fig. 4, *l. s.*) of the sponge is considerably injured. Nevertheless enough remains to show its character. It is smooth and is riddled with evenly scattered pores about 50 μ in diameter. Here and there long slender oxeas protrude.

The wall of the cloaca (pl. 45, fig. 4, *c. w.*) is smooth; not uniformly lined with a fenestrated membrane. It is largely occupied by the open apertures of canals 3–5 mm. in diameter, between which are the mouths of some smaller canals closed in with porous membranes. The sponge is fragile; excavated by numerous canals, many as large as 3–5 mm. in diameter.

The upper surface of the sponge is supported by the tangentially placed clads of abundant triaenes. These are absent over the latero-inferior surface, but a few are found in the interior of the sponge. The latero-inferior surface is supported by the ends of radially placed large oxeas (the strongyle variant is not infrequent), usually grouped in bundles of a few spicules. Through the interior the large skeletal and the long slender oxeas are freely scattered. The parenchyma is further supported by the microxeas with which it is densely filled.

Spicules.—1. Orthotriaene with short rhabdome. Clads 500–1100 by 50–80 μ, characteristic size about 900 by 60 μ; clads of a spicule frequently unequal in length. Rhabdome generally one-third to one-half the length of a clad, occasionally as long as a clad; commonly 250–350 by 50–70 μ.

2. Oxea, large skeletal form. Smooth, slightly curved, tapering evenly to points; 2.5–4.5 mm. by 60–90 μ, with smaller sizes down to 1800 μ by 35 μ. The large sizes are characteristic. The spicule is sometimes strongylate.

3. Oxea, slender form; 1.5–12 mm. by 10–20 μ; common lengths 2–7 mm. The spicule is occasionally strongylate.

4. Small oxea (microxea), about 250 μ by 4 μ.

5. Streptaster, very variable, ranging from the plesiaster to the spiraster; 16–40 µ long; all types abundant and intermingled. Abundant in the dermal membrane, cloacal wall, and canal walls; less abundant in the parenchyma between the canals. The following types are distinguishable:

(*a*) Extreme plesiaster (pl. 45, fig. 6, *a*): total length 40 µ, ray length 25 µ, number of rays 4–5, axis very short.

(*b*) Plesiaster with 5–6 rays (pl. 45, fig. 6, *b*); total length 32 µ, ray length 14–20 µ, axis very short.

(*c*) Metaster with about 9 rays (pl. 45, fig. 6, *c*); total length 24 µ, ray length 12 µ; axis short and curved.

(*d*) Spiraster (pl. 45, fig. 6, *d*); total length 16–20 µ, ray length 6–8 µ, number of rays about 10–12; axis elongated, showing one or two curves.

Holotype.—Cat. No. 21296, U.S.N.M.

In this species the differentiation of two surfaces, virtually an upper and a lower, is noticeable. One of the most marked features of this differentiation concerns the radial megascleres. If we conceive an earlier arrangement in this group to have been that of radial bundles consisting of oxeas grouped round the rhabdome of a triaene, as in species of *Thenea*, we may say that in the evolution of *Sphinctrella bifacialis* the radial bundles have split in two classes, in one of which the triaene alone is represented, in the other only the oxeas.

Genus POECILLASTRA Sollas (1888).

Poecillastra Sollas, 1888, p. 79.

Typically of plate-like form, the one surface bearing pores, the other small evenly dispersed oscula. No specialized pore or oscular areas. Triaenes, often rare, sometimes reduced to triods, occur at the surface in the usual position, with rhabdome radial; similar triaenes, or the calthrops form, are commonly present scattered in the interior. Small oxeas, microxeas of good size, are scattered throughout the sponge; in some species smaller ones, dermal microxeas, are concentrated in the ectosome. Genus extends over toward *Characella* and *Pachastrella*.

Poecillastra Sollas (1888, p. 79) is retained, with Topsent (Topsent 1902*b*, p. 10; Wilson 1904, p. 109), in spite of the fact that it is not sharply separable from *Characella* and *Pachastrella*. Several authors, Lendenfeld, Dendy, Lebwohl, would merge it in *Pachastrella*. But as numerous specific forms become known, what sponge genera are sharply separable?

POECILLASTRA CILIATA, new species.

Plate 37, fig. 3; plate 45, figs. 8, 9.

Station 5424, one specimen. Sponge body a lamella about 2 mm. thick, probably more or less vertical in nature, 60 mm. wide, and

45 mm. high. A broken edge in one region is interpreted as the lower. The remaining and larger part of the edge is rounded and uninjured, evidently free. The lamella is somewhat curved, and the curvature is irregular, but in the region of the free margin one surface is slightly convex, the other concave.

The two surfaces of the lamella are alike in that each is covered with abundant small apertures, often about 100 μ in diameter, but ranging from 60 to 250 μ, the differences in size perhaps being due in part to different degrees of closure. Typically there is one aperture in each mesh of the dichotriaenal reticulum. Each leads into a canal which penetrates the interior of the sponge. Doubtless one surface is the pore, the other the oscular surface, but anatomically they are not distinguishable.

Spicules.—(1) Dichotriaenes (pl. 45, fig. 9), alike on both surfaces, cladomes at the surface, rhabdomes radial. The clads overlap, forming a rather irregular reticulum. Protoclad 100 by 70 μ; deuteroclads 360 μ long, strong; rhabdome 450 by 75 μ, tapering, pointed. A few dichotriaenes occur in the interior, where they occupy no constant position with respect to the sponge surfaces.

(2) Large oxeas, slightly curved, commonly about 2 mm. by 70 μ; passing radially or obliquely through the sponge, the two ends projecting on opposite surfaces; also scattered tangentially and obliquely in interior, some of the internal spicules reaching 3.5 mm. by 80 μ.

(3) Long, slender oxeas, about 850 by 8 μ; spicules projecting, obliquely radial, especially round the rhabdome of the triaenes; inequiended, the outer slenderer end very thin and like a whiplash, often broken off. Alike on both surfaces.

(4) Small oxeas (pl. 45, fig. 8, *a*), classed as choanosomal microxeas, 160–220 by 6 μ, with slight centrotylote ringlike enlargement; very abundant in parenchyma. Spicules offering a transition to the dermal microxea can be found on searching, but they are very few.

(5) Dermal microxeas (pl. 45, fig. 8, *b*), 32–40 by 4 μ; spicule slightly centrotylote; the two halves very slightly bent upon one another, the spicule thus presenting an angular projection at the middle; lying tangentially in the dermal membrane of both surfaces, forming a thin but dense crust.

(6) Streptasters (pl. 45, fig. 8, *c*) of the metaster type, varying toward the amphiaster and plesiaster. Axis short and slightly curved, rays long and slender; rays commonly grouped near the ends of the axis, 3 to 6 at each end. The larger spicules approach the plesiaster type. In end view the spicules appear as oxyasters. Total length of spicule 16–30 μ. In the walls of canals and scattered in parenchyma.

Holotype.—Cat. No. 21290, U.S.N.M.

Genus CHARACELLA Sollas (1888).

Characella Sollas, 1888, p. 91.

Massive, sometimes vaselike, also incrusting. Triaenes localized at periphery of body, in the usual position with radial rhabdome. Microxeas present, sometimes differentiated into larger (choanosomal) and smaller (dermal) ones.

CHARACELLA ABBREVIATA, new species.

Plate 37, fig. 7; plate 45, figs. 7, 10.

D5513, one specimen.

Sponge massive, irregular; attached by under surface. Horizontal diameters 70 mm., 50 mm.; vertical diameter 40 mm. Upper surface feebly hirsute with oxeas projecting 1–3 mm.; latero-inferior surface smooth. Color, light brown.

Dermal membrane riddled with pores, about 100 μ in diameter, lying everywhere between the tangential rays of the supporting triaenes. Numerous small oscula, 0.5 mm. and less in diameter, scattered over the surface in general. On the upper surface is an efferent aperture 9 by 5 mm., crossed by a bar of ectosome, leading into a very shallow cloaca, the wall of which is studded with the mouths of canals, 2–3 mm. in diameter.

Spicules.—(1) Orthotriaene (pl. 45, fig. 10); abundant; clads long, tangential, overlapping, in more than one layer, and constituting an irregular reticulum which supports the dermal membrane; rhabdome short and radial, sometimes aborted and then appearing as a rounded tubercle; all rays smooth, strong, and pointed. Clads 300–800 μ long; characteristic size 600–700 by 50–60 μ. Rhabdome commonly 300–350 μ by 55–70 μ.

(2) Large oxea (pl. 45, fig. 10); characteristic size 2.4 mm. by 80–90 μ; smooth, equiended. Some radial and projecting; others scattered promiscuously in parenchyma.

(3) Choanosomal microxea (pl. 45, fig. 7, *a*); 150–300 by 5 μ; characteristic size 280 by 5 μ. Very abundant throughout the interior, especially abundant around canals.

(4) Dermal microxea (pl. 45, fig. 7, *b*); smooth, spindle-shaped, not centrotylote; 40–60 by 3 μ, commonly about 48 by 3 μ. Abundant in dermal membrane.

(5) Streptasters (pl. 45, fig. 7, *c*); of the amphiaster type. Axis short and slender, about 4 μ long; rays long, slender, tapering, 12–16 μ long; 3–4 rays at each end of the axis; total length of spicule commonly about 30 μ. Rarely a larger form, of the plesiaster type, occurs; total length 48 μ, with only 4 rays.

Holotype.—Cat. No. 21255, U.S.N.M.

The rhabdome of the triaene is, as said, not infrequently reduced in this species to a tubercle. This variation has been fixed, so to speak, in *Nethea*, in which genus the triaenes are not localized at the surface but are scattered through the sponge. (Topsent, 1902*b*, p. 11.)

Family STELLETTIDAE.

Stellettidae SOLLAS, 1888; LENDENFELD, 1903.

The tetraxon megascleres are triaenes, radially arranged. With euasters, some of which are slightly modified in certain species in the direction of streptasters, but without true streptasters or sterrasters. In addition, microrhabds or sanidasters occur in some species.

Dendy (1916) would include in the Stellettidae certain reduced or epipolasid genera, *Asteropus* Sollas and *Jaspis* Gray. I believe it is best, considering all the purposes for which our classification schemes are used, not to follow this practice but to retain the Epipolasidae as a hadromerine (astromonaxonellid) family, thus adhering to objective fact rather than to deductive reasoning. Of course, as everyone knows, it is not possible to do this always and at the same time to avoid practices that are artificial. A case in point is that of *Geodinella spherastrosa* (see p. 322), a species strictly without triaenes and yet one which is undoubtedly assignable to the Geodiidae, since it has all the other very characteristic marks of this family and since the monaxon megascleres are shown by certain vestiges, still recognizable, to be reduced triaenes.

Subfamily STELLETTINAE.

Stellettinae LENDENFELD, 1906, p. 253.

Without a special cloacal tube.

In addition to the genera represented in the collection (*Myriastra*, *Stelletta*, and *Ecionemia*) the subfamily includes the following:

Astrella Sollas (1888, p. 136). Merged in *Stelletta* by Lendenfeld 1903.

Anthastra Sollas (1888, p. 138). Merged in *Stelletta* by Lendenfeld 1903.

Dragmastra Sollas (1888, p. 187) emended, Dendy (1916, p. 237).

Aurora Sollas (1888, p. 187). See Dendy 1916, p. 242, for an important discussion of this genus. He would include certain species (of *Aurora*) strictly without triaenes but which he regards as reduced or "epipolasid" forms—namely, forms in which the monaxon megascleres more or less obviously represent triaenes in which the clads have degenerated. These species are: *Coppatias* (*Rhabdastrella*) *distinctus* Thiele (1900), *Diastra sterrastrosa* Row (1911), and *Aurora cribriporosa*, new species. I prefer to retain *Diastra* Row, and to merge *Rhabdastrella* Thiele in *Jaspis* (*Coppatias*). See Hadromerina.

Ancorina O. Schmidt (1862, p. 51). Sollas (1888, p. 182) includes here forms with a well-developed fibrous cortex, with euasters and sanidasters. Lendenfeld, 1903, enlarges the genus to include several others as subgenera. In 1906 (p. 253) Lendenfeld uses the genus in Sollas' sense plus *Stryphnus*, limiting it to forms with dichotriaenes. The genus is understood by me in Sollas' sense. The question as to the distinction between sanidasters and roughened microrhabds, and the separation of *Ecionemia* from *Ancorina*, is touched upon under *Ecionemia.*

Sanidastrella Topsent (1892 *c*, p. XVIII). To be retained? It would seem there is nothing in the spiculation to mark off the genus from *Ancorina.* The megascleres and sanidasters are essentially the same, and large oxyasters occur in *Ancorina*—as, for example, in *A. wageneri* O. Schmidt, merged in the type species, *A. cerebrum* O. Schmidt, by Lendenfeld, 1894, p. 29, the ray length here reaching 45 µ (Sollas, 1888, p. 189; Lendenfeld, 1894, p. 35).

Rhabdodragma Dendy (1916, p. 239). Distinct from *Ecionemia?*

Stryphnus Sollas (1888, p. 171). Lendenfeld, 1903, 1906, makes it a subgenus of *Ancorina.*

Algol Sollas (1888, p. 200). Subgenus of *Ancorina* in Lendenfeld, 1903; presumably also in Lendenfeld, 1906.

Penares Gray (1867, p. 542). Equivalent to *Papyrula* O. Schmidt, as used by Sollas, 1888, p. 198. Stellettids with small, smooth oxeas usually controtylote, which are densely aggregated in the ectosome. This small oxea, or " microxea " Authors, is a very different spicule from the micorhabd of *Ecionemia*, as is shown not only by its shape but by its much greater and very variable size. The length of the spicule ranges in the type species, *P. helleri* (O. Schmidt), from 20 to 175 µ, its thickness from 2 to 10 µ (Lendenfeld, 1903, p. 61). In *P. sollasi* Thiele (1900, p. 23), the spicule ranges in length from 26 to 90 µ; in *P. foliaformis* Wilson (1904, p. 114) from 60 to 160 µ; in *P. obtusa* Lendenfeld (1903, p. 263) from 100 to 150 µ; in *P. sclerobasa* Topsent (1904, p. 83), the length is 100 µ, thickness at the middle 12 µ.

Dercitus Gray. Position? See p. 277.

Calthropella Sollas. See p. 278.

Chelotropella Lendenfeld. See p. 278.

Appendix—Papyrula O. Schmidt (1868, p. 18. Sollas, 1888, p. 199. Lendenfeld, 1903, p. 69) may be provisionally retained for forms differing from *Penares* in the absence of euasters. Lendenfeld, 1906, p. 227, regards the small oxeas as derived from metasters and enrolls the genus in the Theneidae.

Genus MYRIASTRA Sollas (1888).

Myriastra Sollas, 1888, p. 112, plus *Pilochrota* Sollas, 1888, p. 120.

The ectosome is sometimes simple and collenchymatous, sometimes differentiated to form a fibrous cortex. Microscleres are euasters of one sort.

Lendenfeld (1903, 1906) merges *Myriastra* in *Stelletta* O. Schmidt. In this he is followed by Hentschel (1912). Dendy, on the other hand, retains (1905, 1916, 1916b) the genus, in which, doubtless with justice, he merges (1916) the forms which have an ectosome that is differentiated into a cortex and which have been grouped by many (Sollas, 1888; Wilson, 1902; Topsent, 1904; Dendy, 1905; Row, 1911; Stephens, 1912) under *Pilochrota* Sollas.

MYRIASTRA CLAVOSA (Ridley).

Plate 37, fig. 6.

Stelletta clavosa Ridley, 1884, p. 474.
Myriastra clavosa Sollas, 1888, p. 116.

Of this well-known species, a large number of specimens were taken, in different localities. All specimens spheroidal, with the horizontal diameter usually somewhat greater than the vertical; horizontal diameter ranging from 5 to 22 mm. The data as to color differences are, as is usual with collection material, scarcely more than suggestive. The color is sometimes whitish gray or light brown, sometimes reddish or pinkish brown, often greenish, sometimes greenish with patches of dull reddish purple. Some of the specimens are with embryos. In the great majority of the specimens there is a distinctly developed cloaca.

Station D5141. Eight specimens, 8–13 mm. in diameter, intergrading between classes "with cloaca" and "without cloaca." (See below.)

D5145. Nine specimens, 8–12 mm. diameter, with distinct cloaca. Seventeen specimens, 8–12 mm. in diameter, without distinct cloaca.

D5158. About seven dozen specimens, 11–20 mm. diameter, with distinct cloaca. A dozen specimens, 9–14 mm. in diameter, without distinct cloaca.

D5160. Twenty specimens, 13–22 mm. in diameter, with a cloaca. Two sponges have fused with one another, by the side.

D5174. Three specimens, about 10 mm. in diameter, with distinct cloaca.

D5205. Sixteen specimens, 5–10 mm. in diameter, with distinct cloaca except in some of the smallest.

D5218. Nine specimens, 18–21 mm. diameter, with a cloaca.

The species is a common one, occurring widely in East Indian waters (China Sea, Ternate, Amboina, Torres Straits, etc.) and in the neighboring part of the tropical Pacific (Lendenfeld, 1903, p. 48; 1906, p. 287; Hentschel, 1912, p. 310).

The shape is recorded as spheroidal, usually oblate (Ridley, 1884, p. 474; Sollas, 1888, p. 116; Topsent, 1897, p. 433; Lindgren, 1898, p. 331; Lendenfeld, 1903, p. 48; 1906, p. 287; Hentschel, 1912, p. 310), the diameter ranging from 5 to 14 mm. Only in the case of an isolated specimen, considered by Topsent (1897, p. 433) to belong to this species, is a different shape recorded. This specimen is a relatively large one, of compressed shape, 45 mm. high, 40 mm. wide, 10–20 mm. thick, exhibiting on its upper border two oscula 3–4 mm. wide. Details are not given, except that in the chiasters the rays are tylote or minutely tuberculate. In view of the general uniformity as to shape and size in the species, possibly this specimen would best be enrolled as a variety.

The recorded colors embrace yellowish, greenish white, a purplish tint, grayish brown, blackish brown, reddish white. It would seem that the natural color, if at all constant, includes green and purple tints.

In my specimens, as in the others found (see Sollas, 1888, p. 116), the pores are uniformly distributed in sievelike areas. The ectosomal trabeculae between these areas, which are often about 200 µ wide, contain the clads of the dichotriaenes, the surface appearing reticular. The stratum of small subdermal chambers into which the pores open directly, and which largely fill the ectosome (Sollas, 1888), is present. But I do not find that these chambers are divided by horizontal partitions into outer and inner portions (Sollas). From the chambers incurrent canals pass radially into the interior. But these, together with the radial skeletal bundles stop short of the central region, which thus lacks a radiate arrangement.

Variation in the cloaca. A small cloaca, opening by an osculum in the center of the upper surface, is a characteristic of the species. Sollas gives the most precise statements, but the cloaca described is exceptionally small. (See Lendenfeld, 1906, pl. 29, fig. 7.) He says (1888, p. 117) that the cloaca is in the shape of a short cylindrical tube about 1 mm. deep by 0.725 mm. wide, opening by an osculum surrounded by an oscular membrane. In the accounts of some other specimens it remains uncertain whether a distinct cloaca was present. In Dendy's specimens, for instance, from Ceylon, all small, 9 mm. or less in diameter, there is only "a single, slightly depressed vent" (1905, p. 72).

In the great majority of my specimens a distinct though small cloaca is present, opening by an osculum, surrounded by an oscular membrane, which occupies the center of the upper surface; numerous small efferent canals opening into the cloaca. The cloaca is rounded or conical in shape, commonly 2–4 mm. deep, 2–4 mm. wide, the osculum 1–2 mm. wide. The cloaca typically extends inward symmetrically toward the center of the sponge (pl. 37, fig. 6, right). But in some specimens it extends inward very obliquely (pl. 37, fig. 6, left).

In a small yet considerable minority of the specimens a distinct cloaca is not developed. Instead, the osculum, remaining apical as usual, is simply the aperture of a single small efferent canal. Or in place of cloaca and osculum there is only a most minute depression into which several small efferent canals open. Such specimens occur along with the common type in the same locality. Many of them are small, but some are of good size, 10–14 mm. diameter. There is intergradation between the two classes in the same locality. The facts indicate that with continued growth there is a strong tendency in the species to develop a cloaca, but that this tendency is inhibited, or possibly is germinally weak, in some individuals, which therefore reach a considerable size, 14 mm. in diameter or thereabouts, without developing a cloaca.

Table giving data for nine individuals concerning variation in the cloaca.

		Diameter of sponge.	Cloaca.	Diameter of osculum.
		Mm.		Mm.
Individuals with well developed cloaca.	Sponge 1	18	Rounded at bottom, 3 mm. deep, 3 mm. wide.	1
	Sponge 2	17	Funnel-shaped, 4 mm. deep, 2 mm. wide.	1
	Sponge 3	16	Funnel-shaped, 3 mm. deep, 2 mm. wide.	1¼
	Sponge 4	16	Rounded at bottom, 2 mm. deep, 3 mm. wide.	1½
Individuals with reduced cloaca	Sponge 5	19	2½ mm. deep, 1½ mm. wide	¾
	Sponge 6	13	1½ mm. deep, 1½ mm. wide, extending in somewhat obliquely.	½
	Sponge 7	11	1¼ mm. deep, 2 mm. wide	1
Individuals without a cloaca.	Sponge 8	13	Represented by a narrow efferent canal 2 mm. long, ½ mm. wide, extending in obliquely from the osculum.	½
	Sponge 9	11	Represented by a minute depression ¼ mm. deep, ⅓ mm. wide, into which 3 or 4 small efferent canals open.	⅓

The spicules, in respect to details of shape and dimensions, are not far from those recorded by Ridley, Sollas, etc., as may be seen from the following data.

1. Dichotriaenes. Cladomes of the larger lie in the dermal membrane. Rhabdome 2.7 mm. by 40–50 μ; protoclad 90–120 μ long; deuteroclads 200–220 μ long, reaching in some specimens 300 μ.

Lendenfeld (1906, p. 288) finds that internal to the subdermal spaces lies a second layer of dichotriaenes. This is so in my specimens. The facts further indicate that the dichotriaene begins deep in the choanosome as a protriaene, that it grows and differentiates as it passes toward the surface. The facts are as follows:

The dichotriaenes beneath the subdermal cavities are smaller than those of the outer layer. The difference especially concerns the deuteroclads, which are about 150 μ long. Internal to these are still other and smaller, obviously developing, dichotriaenes with deuteroclads, which vary in length, but which are all short and, indeed, in many cases minute. I give measurements of two spicules:

Rhabdome.	Protoclad.	Deuteroclads.
1300 by 18 μ.	90 μ long.	30 μ long.
1000 by 16 μ.	100 μ long.	5 μ long.

Internal to these, and still smaller, are protriaenes, which vary in size down to quite small spicules. The clads of the protriaenes represent, I believe, the protoclads of the later (dichotriaene) stage. I give the following measurements for the protriaenes:

Rhabdome.	Clads.
1,000 by 14 μ	120 μ long.
800 by 14 μ	100 μ long.
900 by 14 μ	80 μ long.
600 by 14 μ	70 μ long.
600 by 14 μ	56 μ long.
500 by 7 μ	44 μ long.
450 by 7 μ	40 μ long.
320 by 10 μ	40 μ long.
300 by 7 μ	32 μ long.

From the measurements given above it will be seen that there is a very complete transitional series, ranging from the small deep-lying protriaenes to the well-developed dichotriaenes. It is thus fairly certain that the former are only stages in the development of the latter.

2. Anatriaenes. Cladome about hemispherical. Rhabdome 2200 by 24 μ; clads 75–120 μ long, and stout. They accompany the dichotriaenes. Some of them pass out quite to the surface, their cladomes lying external to those of the dermal dichotriaenes. Quite small anatriaenes with very flat, shallow cladomes, lie intermingled with the developing dichotriaenes (see above). These doubtless are stages in development.

A detailed examination would probably show that the cladomes of the anatriaenes are well stamped with the "geographical mark"—that is, that in respect to this point, a quantitative one, the difference beween specimens from different localities is easily perceived. For instance, in a specimen from D5158 the cladomes were shallower than hemispherical, about umbrella-shaped, with clads 75 μ long.

While in a specimen from D5218 the cladomes were a little deeper than hemispherical, with clads 120 μ long.

3. Skeletal oxea, 2,000 by 24 μ and smaller. Together with the shafts of the triaenes in the radial skeletal bundles, and strewn irregularly in the central part of the sponge.

4. Cloacal oxea, small and slender; 250–340 by 5 μ. Tangentially strewn in cloacal wall; tangential in oscular membrane, radiating toward osculum. In Sollas' specimens these spicules were 9 μ thick, traversed the cloacal wall radially, projecting and making the cloacal wall hispid. In Lendenfeld's specimens (1906, p. 287) the spicules are closer to mine in thickness, 180–250 by 4–6 μ; probably radially arranged, since there is no statement to the contrary.

5. Chiasters, 8–12 μ in diameter, abundant at the surface and in choanosome. In general smaller at the surface than in interior. Rays long and slender, and distinctly tylote; rays 6–10 in number; as usual, the fewer the rays, the larger the spicule.

This agrees well with the records of Ridley (1884) and Sollas (1888). Lendenfeld (1906, p. 287), however, finds that in his specimens, when the chiasters are examined with an immersion objective, they turn out to be "acanthtylasters"—that is, the rays, 3–12 in number and cylindrical in shape, are armed at the end with a cluster of spines and may be minutely spined along their course; total diameter of spicule 6–16 μ, the size inversely as the number of rays. Sollas (1888, p. 119) had already found chiasters of this type in a specimen which he described as *M. toxodonta*, and which Topsent (1897, p. 433) merged in *M. clavosa*. Topsent's synonymy has been generally accepted. Lendenfeld assumes that the chiasters in the species are always "acanthtylasters," and hence that the variability, which is to be inferred from the records, is really due to the fact that the spicules have usually not been examined with a high objective. This conclusion, to be sure, remains to be tested.

My own observations confirm Lendenfeld in the essential matter. In two specimens (from D5158) examined for this point, the enlargement, in which a ray terminates, was found not to be a ball but an expansion subdivided into minute spines. This terminal expansion seemed to be flattened, and the number of spines about 5; the expansion, when seen endwise, looking something like a little star. The rays of the chiaster itself are approximately cylindrical, taper a little toward the end, and are in general without spines along their course but now and then show one.

MYRIASTRA SIEMENSI (Keller).

Stelletta siemensi KELLER, 1891, p. 341.—LENDENFELD, 1903, p. 36.

Station D5478, one specimen attached below to a *Euspongia irregularis*.

The sponge is irregularly spheroidal with a greatest diameter of 65 mm., and is thus somewhat larger than any of Keller's specimens. The aperture of the apical cloaca is 12 mm. wide; cloaca and apertures of efferent canals as in Keller's specimens (pl. 19, figs. 50, 51), color much the same, also consistency.

Sections radial to surface show the features illustrated in Keller's figure 56 (pl. 20); except that the actual surface is well preserved in the *Albatross* specimen. Thus distal to the cladomes of the orthotriaenes is a thin layer of ectosome. The fibrous layer occupies the rest of the ectosome and is about 600 µ thick. The pores, chonal canals, subcortical crypts, and radial canals are all as in Keller's figure, except that the actual pores are small. Flagellated chambers of same size as in Keller's types.

The megascleres have the same arrangement as in Keller's types (pl. 20, fig. 56) and are of about the same size. The anatriaenes differ in having a deeper cladome. The details are as follows:

In the orthotriaenes, the rhabdome is 1 to 2.2 mm. long, 40–80 µ thick below cladome; clads 135 to 210 µ long, 35 to 70 µ thick at base. Orthotriaenes are abundant. Surface preparations show the clads meeting or overlapping and thus surrounding angular or rounded areas, often about 175 µ in diameter, in which the pores may be seen.

In the anatriaenes, the rhabdome is 2 to 2.5 mm. long, 20–35 µ thick below cladome; cladome deep or fairly deep, clads strong and 120 µ long.

The larger oxeas measure about 1.5 mm. by 20–24 µ.

In Keller's types the asters are "very small and delicate" oxyasters with 7–9 rays and about 10 µ in diameter. Similar asters occur in some abundance in both ectosome and choanosome of the *Albatross* sponge. Tangential sections show that they are quite abundant at the extreme surface, where they range in total diameter 8–12 µ. In the interior the total diameter ranges 8–16 µ. There is "no centrum," the rays are very slender and even under an immersion objective show no distinct terminal enlargement, although at such a magnification they appear slightly roughened.

Keller finds microspheres, about 5 µ in diameter, very abundant in spots in the choanosome. Colorless spherules up to this size occur also in the *Albatross* sponge in ectosome and choanosome, sometimes scattered but often in dense groups. Appearances suggest that there is perhaps some relation between such groups and the spheruliferous cells mentioned below.

Keller's sponges all contained peculiar masses of a problematical nature. These formed a single and nearly continuous layer in the outer part of the cortex (p. 342, pl. 20, figs. 56, 57), were spheroidal or ovoidal in shape, about 100 µ in diameter, and of a dark-brown color (yellowish in the figure given). Each mass is said to be a heap of most minute spheres ("winziger Kugeln") which are held together by a cement substance, and round each mass is a follicular epithelium. Keller thinks it likely that the masses (or only the cement substance?) are made up of spongin.

A conspicuous feature of a radial section through the *Albatross* sponge is a layer of bodies having about the same distribution and general appearance as the above. My material is doubtless better preserved than Keller's, and I find the masses to be groups or nests of spheruliferous cells ("cellules spheruleuses" of Topsent). The data are as follows: As seen in radial sections the masses are arranged in a single layer outside the fibrous stratum of the cortex, between it and the actual surface. The layer is interrupted by the radial megascleres and cortical canals; otherwise it is almost continuous. The masses, 100–160 μ in diameter, have, except near the surface, a sharp boundary. The lower and major part of each mass is more or less spheroidal in shape and is outlined by a thin but fairly conspicuous layer which is not a special cellular follicle but only a condensation of the surrounding mesenchyme. The masses are yellow in color.

Each of these problematical masses is a densely or loosely packed group of spheruliferous cells. The cells are 8 μ in diameter, and when stained with haematoxylin show a central nucleus. The cell body is entirely filled with minute spherules about 1 μ in diameter and yellow in color. A few spheruliferous cells of this kind may also be found scattered in the ectosome. Close to the surface of the sponge at the level of the triaene cladomes the nests of spheruliferous cells meet and fuse with one another in irregular fashion. This is best seen in tangential sections. Distal to the cladomes there is a very thin layer of the minute yellow spherules themselves. In this situation the spherules are no longer aggregated in cell groups. They must have broken out of the cells which produced them. They are best seen in thin tangential sections of the surface, where they appear, in places at any rate, as a single and continuous layer, on which are scattered the minute asters. The function of this superficial layer of spherules can only be guessed at.

It may be noted that a closely crowded superficial layer of granular cells has been recorded in other Stellettidae—as, for example, in *Stelletta crassiclada* (Lendenfeld, 1906, p. 281).

Genus STELLETTA O. Schmidt (1862).

Stelletta O. SCHMIDT, 1862, p. 46.

With or without a fibrous cortex. Microscleres are euasters of two kinds, one forming a dermal layer from which the other, the larger, is excluded.

Sollas (1888, p. 150) restricts the genus to forms with a fibrous cortex and well differentiated chones. Lendenfeld (1903, p. 33) enlarges the genus, merging in it numerous genera recognized by Sollas. Dendy (1905, p. 77) extends the genus in Sollas' sense to include forms with and without a fibrous cortex, the genus remaining characterized by the microscleres, euasters of two kinds. Lendenfeld (1906, pp. 252–53, 264) uses the genus to include forms in which the microscleres are euasters, one or two kinds, with, in some species, trichodragmas (orthodragmas of Sollas, dragmas of Lendenfeld); the genus thus including not only *Stelletta* in Dendy's sense (as used here) but *Myriastra* Sollas (plus *Pilochrota* Sollas, *Astrella* Sollas, *Anthastra* Sollas, *Dragmastra* Sollas, and *Aurora* Sollas.

STELLETTA RADICIFERA, new species.

Plate 37, fig. 2; plate 45, figs. 3, 11, 13.

D5179, one specimen.

More or less pear-shaped, the small end representing the upper end of the sponge. Height 25 mm., thickness at the middle 18 mm. Upper half of body smooth; lower half coarsely hirsute with downwardly projecting spicules, many protruding several millimeters and doubtless serving as roots. Color, brown.

A minute osculum, point-like in size, present at the apex of sponge. The pores are closed but the distribution of the dermal oxyasters indicates that they are scattered everywhere in the spaces bounded by the cladomes of triaenes, and have a diameter in the neighborhood of 40 µ. Probably in a certain physiological phase definitely outlined pore-areas appear.

The ectosome is about 140 µ thick, largely occupied by small subdermal cavities which are roofed over by a very thin dermal membrane. The ectosome is not histologically differentiated into a "cortex." But the deepest layer, which forms the floor of the subdermal cavities, is noticeable as a thin, fairly compact, brownish stratum, somewhat fibrous in the sense of being made up of horizontally elongated cells. Below this stratum is a zone of comparatively large rounded cavities, and similar spaces are abundant throughout the interior, there being a high ratio of cavity to solid tissue. Sponge tissue is delicate.

Closely set radial spicular bundles pass from an excentric point of the interior, much nearer the upper than the lower pole, to all points of the surface. There is no "nucleus" (the "nucleus" of the literature appears to be a spheroidal kernel containing practically no sponge tissue, made up of the inner ends of the radial skeletal elements which here come together and form a compact mass).

Spicules.—(1) Dichotriaenes (pl. 45, fig. 11). The chief radial spicule; cladomes at the surface supporting the dermal membrane.

overlapping so as to enclose polygonal areas: other cladomes deeper in the ectosome. Rhabdome 3.4–5 mm. by 44 μ; protoclad 80 μ long; deuteroclads 100–190 μ long. The intermingled smaller spicules with very short deuteroclads are doubtless young forms, and indicate that the protoclad reaches its full length although not its thickness while the deuteroclads are very small.

Among the projecting spicules of lower half of body are some dichotriaenes.

(2) Anatriaenes (pl. 45, fig. 13). Present but not abundant in the radial bundles. Cladomes in ectosome and peripheral choanosome. Cladome rather shallow, apex rather sharp. Rhabdome may be as long as 8 mm.; 10 μ thick. Clads 40–60 μ long. Similar anatriaenes occur among the projecting spicules of the lower body, probably abundantly, but the ends are more often broken off. The clads are sometimes reduced, spicule becoming an anamonaene; clad up to 70 μ long, rhabdome 8–16 μ thick.

(3) Protriaenes (pl. 45, fig. 13). A few present in the radial bundles, cladome in the ectosome. Rhabdome long, 8 μ thick; clads 60–100 μ long. Similar protriaenes, with rhabdome 4.5 mm. by 8 μ, and clads 20–60 μ long are abundant among the projecting spicules of the lower body. Stronger protriaenes also occur among these projecting spicules; rhabdome 40 μ thick at the thickest point, tapering somewhat toward outer as well as toward inner end; clads strong, 50–85 μ long, sometimes rounded at the apex instead of pointed, sometimes unequal in length.

(4) Oxea. Abundant in the radial bundles; 3.4–4.5 mm. by 35–50 μ. Also among the projecting spicules of the lower body, where the thickness may reach 70 μ.

(5) Dermal oxyaster (pl. 45, fig. 3, *a*). Abundant, forming a crust. With small centrum and relatively long tapering rays. Total diameter, 8 μ.

(6) Oxyasters of interior. (*a*) Ectosomal oxyasters (pl. 45, fig. 3, *b*, *c*) abundant, 8–20 μ diameter, varying from a type without obvious centrum and 6–7 rays to a type with conspicuous centrum and more numerous rays. The centrum is most conspicuous and the rays most numerous in the largest spicules, but these are scanty. The spicules commonly range 12–16 μ in diameter, have a perceptible centrum and a number of rays greater than in the choanosomal type. (*b*) Choanosomal oxyasters (pl. 45, fig. 3, *d*) scantily present. About 16 μ diameter, with a few (6–7) long slender rays; without centrum. The asters of all the types intergrade.

Holotype.—Cat. No. 21301, U.S.N.M.

The *Albatross* species, as will have been seen, has the following complex of megascleres: Oxeas, dichotriaenes, anatriaenes, protriaenes. The only recorded species of the genus, *sens. str.*, having the same complex are certain Japanese forms. The probability is that all the forms with this complex are very closely related. The Japanese forms alluded to are *S. orientalis* Thiele (1898, p. 14), the surface of which is covered with a furze consisting largely of protriaenes; *S. validissima* Thiele (1898, p. 13), with protriaenes having clads 200 μ long, with dermal strongylasters, and with choanosomal oxyasters having many rays.

STELLETTA RADICIFERA, var. ROBUSTA, new variety.

An imperfect specimen from the same station (D5179) as the above possibly belongs in the same species. Preparations of the two are, however, easily distinguishable, and it would therefore be arbitrary to combine them, although the differences may be found to fall within the range of individual variation.

This sponge which I provisionally designate a new variety differs from the type in the following points:

(1) The dichotriaenes are larger. The rhabdome is 5–6 mm. by 70–85 μ: protoclad 100–120 by 60 μ; deuteroclads 210–260 μ long.

(2) The anatriaenes are larger. The rhabdome is 6–10 mm. by 32 μ, clads 70–100 μ long.

(3) The oxeas seem to reach a greater common average of size. At any rate spicules 5 mm. by 50 μ were easily found.

(4) The dermal oxyasters are somewhat smaller, 6–8 μ in diameter.

(5) Among the ectosomal asters, the large type, 20 μ in diameter, with conspicuous centrum and many rays, is much more abundant. The centrum is typically about one-fourth the total diameter, sometimes reaching one-third the total diameter.

(6) The thin, brown, semifibrous layer in the deepest part of the ectosome is not present.

The specimen, as said, is imperfect. It is hemispherical and probably represents the upper part of a subspheroidal sponge, the lower half of which has been torn away. Horizontal diameter 25 mm.. No oscula discoverable. Surface smooth and entirely covered by a thin layer of débris which obscures the pores. Color, very light brown.

Genus ECIONEMIA Bowerbank (1864).

Ecionemia Bowerbank, 1864, p. 173.—Sollas, 1888, p. 195 plus *Psammastra* Sollas, 1888, p. 174.

The ectosome may or may not be sufficiently fibrous to constitute a cortex. The larger triaenes supporting the dermal surface are usually plagiotriaenes (sometimes orthotriaenes or dichotriaenes). The microscleres include microrhabds which typically are minute roughened strongyles forming a dermal layer. The euasters are typically chiasters, rays tylote (tylaster) or not; the rays sometimes spinous, especially at the end (acanthtylaster); or, again, the rays stoutly strongylate (strongylaster); oxyasters and small spherasters with oxeate or strongylate rays may also occur.

Sollas (1888, p. 195) restricts the genus to forms in which the ectosome does not form a fibrous "cortex." Dendy (1905, pp. 80–81) gives sufficient reason for including both kinds of forms, those in which the ectosome is not, or possibly is not, fibrous and those in which it is more or less fibrous. This entails merging *Psammastra* Sollas, covering species with a cortex (Sollas 1888, p. 200), in *Ecionemia.*

Dendy (1916, p. 241) would exclude forms with trichodragmas, assigning these to his new genus *Rhabdodragma* (1916, p. 239).

Lendenfeld (1903, p. 61) makes *Ecionemia* a subgenus of *Ancorina*, but extends the conception to include forms listed by Sollas under several other genera.

Lendenfeld (1906, p. 253) restores *Ecionemia* as a genus. He would exclude forms with dichotriaenes, reserving *Ancorina* for the reception of these. He would also exclude forms in which the euasters are oxyasters, using *Sanidastrella* for these. Dendy (1905, p. 81) on the contrary includes forms with dichotriaenes and forms with oxyasters (1916, p. 242), a usage which seems to me necessary. This being so, what remains to distinguish *Ecionemia* from *Ancorina?* (1) The few recorded species of *Ancorina* have a well developed fibrous cortex. This is less strongly developed or possibly absent in the *Ecionemia* species. But this is not much of a reason for separating the two groups. (2) The separation of the two genera nominally rests on the distinction drawn between the sanidaster of *Ancorina* and the roughened microrhabd of *Ecionemia.* Lendenfeld has consistently refused to recognize this distinction. And others, as Dendy (1916, p. 239), think "the so-called sanidaster merges into the microrhabd type of spicule." This would seem to be the case. The sanidasters of the type species of Ancorina, *A. cerebrum* O. Schmidt, are described by Lendenfeld (1894, p. 35) as 5–8 μ long with numerous blunt spines, and such a spicule is certainly not far from the microstrongyles of *Ecionemia.* Probably then *Ecionemia* should even now be merged in *Ancorina.*

ECIONEMIA CRIBROSA Thiele.

Ecionemia cribrosa THIELE, 1900, p. 31.

Thiele's species is from Ternate. With it I identify a specimen from Station D5179. Lendenfeld (1903, p. 65) merges this species in another of Thiele's species, *E. agglutinans*, also from the Moluccas, but there is some difference in the records of the two forms. *E. cribrosa* falls in the group of *Ecionemia* species in which small, radial, ectosomal oxeas are present.

The *Albatross* sponge is more or less spheroidal, about 15 mm. in diameter, attached to the inside of a *Crepidula* shell. The color is dark brown at the surface, lighter below the ectosome. There are two small oscula about ¼ mm. in diameter on the upper surface near the equator.

Thiele says (1900, p. 31) in three of his specimens the pores are in closely set, commonly oval, areas, the intervening trabeculae forming a network. A fourth specimen, tentatively assigned to a variety, *micropora*, had inconspicuous, much smaller, pore areas.

Over a part of the surface of the *Albatross* specimen similar pore areas are visible to the eye as closely set small whitish patches separated by the brown ectosome. Such areas are about 300 μ or less in diameter, angular in shape, sometimes rosette-shaped—namely, with rounded lobes; about 6–7 pores in an area, pores about 20 μ in diameter. The intervening trabeculae of ectosome may be as wide as, or narrower than, the areas. Where such areas are most distinct the pores are for the most part closed. Elsewhere on the surface of this specimen the pores are fully open and "pore areas" do not exist. Instead the entire dermal membrane is uniformly riddled with pores. Through it ectosomal trabeculae separating the subdermal spaces can be vaguely seen. Transitions between these two states occur and it is clear that they represent different physiological phases. That is, where the sponge is expanded and the pores all open there are no areas. As the sponge loses water and the pores close, "pore areas" appear. Doubtless the events are about as follows: Above the larger spaces in the ectosome, what are denominated the subdermal chambers, the pores are slow in closing. In the regions between such spaces the pores close first of all and the pigment cells quickly invade the dermal membrane from the deeper strata of the ectosome. This brings on the appearance of brown trabeculae separating the "areas."

A further inspection of the surface of this sponge shows that as the pores continue to close quite small areas including only two or three pores may be left, well separated by brown ectosome. Doubtless the specimen for which Thiele suggests the name, var. *micropora*, was in this phase when preserved. It seems probable that after complete and prolonged closure of the pores the whole surface of the sponge might become uniformly brown. It can not be said that the "pore areas" make a specific mark, for they may or may not be there. What is possibly specific, however, is a general and subtle complex of anatomy and habit which results in the appearance of pore areas in a certain physiological phase.

As in Thiele's specimens, the ectosome is about 300 μ thick and contains an abundance of spheruliferous pigment cells. These extend into the choanosome along the radial skeletal bundles. The inner zone of the ectosome is densely fibrous and 40–60 µ thick; in it the pigment cells are only scantily present and distinctly flattened. Above the fibrous layer the ectosome contains abundant small rounded subdermal spaces, into which the pores open directly, piercing the dermal membrane. The subdermal spaces connect at the level of the fibrous layer with larger spaces, the subcortical crypts. These are more conspicuous than the subdermal spaces. The arrangement constitutes a variant of that shown in Sollas' diagram (fig. 7, *A*, p. XXIV, 1888). The choanosome contains some canals of relatively good size, but in general is compact.

The radial skeletal bundles are closely set, expand at the surface, converge internally, but by no means reach the center of the sponge.

The spicules closely approximate in shape and measurements those of Thiele's specimens, as will be seen from the following:

1. Skeletal oxea, reaching 2.5 mm. by 60 µ; in radial bundles, also scattered.

2. Plagiotriaenes, in radial bundles. Rhabdome 1.5–2 mm. by 60 µ. Clads in general lie at the surface; strong, 120–175 µ long. Younger ones, as usual, with cladomes deeper in the ectosome or in the outer part of the choanosome. Thiele (1900, p. 32) designates this spicule an orthotriaene; length of clad about 250 µ. But his figure shows that it is assignable to the category of plagiotriaenes, where Lendenfeld (1903) puts it.

3. Anatriaenes, in radial bundles; abundant. Rhabdome 3 mm. by 24 µ. Cladome deep, clads 80–120 µ long, strong. Cladomes generally in ectosome, close to the surface.

4. Protriaene. Rhabdome 15 µ thick, clads 40 µ long. Only one found protruding from the surface; the sponge was well searched over for this form of spicule. The protriaene may possibly be only an occasional variant of the characteristic triaene. Or, as Thiele suggests, it may possibly be a fairly constant element in the spiculation of the genus, though usually broken off and overlooked.

5. Ectosomal oxea, 250 by 3 µ. Radial to the surface, in ectosome. Abundant, but the individual spicules spaced well apart from one another. The spicule is equiended, this feature constituting a minute point of difference from Thiele's specimens.

6. Microstrongyles. Straight, a little thicker in middle than at ends, minutely roughened; 10–12 µ long by 2–3 µ. Crowded at, and close to, the surface, forming a dermal crust. Scantily present deeper in the ectosome and in choanosome.

7. Chiaster, mostly about 8 µ diameter, with very small centrum, and 6–9 long slender rays, not obviously tylote. Scantily present in ectosome and choanosome. Larger ones, 12 µ in diameter, with distinctly tylote rays, are occasionally found in choanosome.

The form evidently can not be separated from Thiele's species.

Subfamily TETHYOPSINAE.

Tethyopsinae Lendenfeld, 1906, p. 253.

With a special cloacal tube.

In addition to *Tethyopsis*, the subfamily includes the following genera: *Tribrachion* Weltner (1882, p. 50) (=*Tribrachium*, Sollas 1888, p. 153). (See also Lendenfeld, 1903, p. 67; Lendenfeld, 1906, p. 253). *Disyringa* Sollas (1888, p. 161). (See Lendenfeld, 1906, p. 290.)

Genus TETHYOPSIS Stewart (1870).

Tethyopsis Stewart, 1870, p. 281.

The cloacal tube contains several excurrent canals. Without sanidasters. One of the euaster forms may be slightly modified in the direction of a streptaster. Trichodragmas may occur.

TETHYOPSIS DUBIA, new species.

Plate 37, fig. 4; plate 45, figs. 12, 14, 15.

One specimen from D5163.

Sponge spheroidal, 15 mm. in diameter, attached to a shell on one side and much incrusted with shelly débris. The cloacal tube protrudes about 5 mm. It is 5 mm. wide at its base, slightly narrower at the free end. It contains four equal longitudinal canals, each about 1.5 mm. in diameter, all freely open at the upper end (in the actual specimen). The walls of the canals are very thin. They are plainly distinguishable from one another in cross section of the tube and are marked off from one another on the surface of the tube by slight longitudinal furrows. Thus the entire cloacal tube presents the appearance of being a fusion of four subsidiary tubes.

Pores are abundantly scattered over the surface of the body, which is somewhat uneven owing to the fact that the dermal membrane is elevated on the points of the cladi of the triaenes. The ectosome forms a very distinct translucent layer about 600 μ thick, which includes large subdermal spaces. The ectosome is fibrous in its outermost portion, and again where it borders upon the choanosome it includes a fibrous stratum, about 175 μ thick.

The radial megascleres, chiefly plagiotriaenes, proceed from the center to all points of the surface. They are so abundant as not to form distinct bundles. The system of radial triaenes is continued into the walls of the subsidiary cloacal tubes, but the spicules are here modified into orthomonaenes and orthodiaenes, the rhabdomes lying longitudinally, the cladi extending circularly, in the tube wall.

Spicules.—(1) Plagiotriaenes (pl. 45, fig. 14), small; clads 175–300 μ long, strong; rhabdome 3.3–4 mm. long, about 90 μ thick. The clads lie at the surface, supporting the dermal membrane, also in the deeper layer of ectosome below the subdermal cavities. Younger forms, of course, occur, the clads of some of them lying in the outermost part of the choanosome.

(2) Oxeas: equiended, smooth, tapering gradually toward each end; intermingled with the triaenes of the body and cloacal tube; 3.7–4.7 mm. long by 50–70 μ wide.

(3) Orthodiaenes and orthomonaenes, chief megascleres in the walls of cloacal tube. The characteristic spicule (pl. 45, fig. 15*b*) is a diaene that is nearly a monaene; rhabdome 3.7–4.4 mm. long, 35–50 μ thick; developed clad long, reaching 1,750 μ in length, about 35 μ thick, frequently somewhat sinuous; vestigial clad very short, often more or less curved or bent. The vestigial clad reaches a considerable development in some spicules, remaining shorter, however, than the other clad. In some of the diaenes (pl. 45, fig. 15*a*) in the basal region of the cloacal tube the long clad is dichotomous, the secondary clads usually unequal in length.

These modified triaenes of the tube walls are closely and elegantly combined, forming a firm skeleton, the rhabdome playing the part of a longitudinal element, the clads that of circular elements.

(4) Strongylasters (pl. 45, fig. 12, *a–d*), not strictly euasters, but representing a step from the euaster toward the streptaster type. Densely abundant in the dermal membrane of the body and cloacal tube, forming a crust; also abundant in the ectosome, and extending into outer part of choanosome. The presence of an axis in (all of?) these spicules taken in connection with the fact that the genus is obviously related to the Stellettidae rather than to the Theneidae, suggests (*a*) that a series of changes may convert a euaster into a true streptaster and (*b*) that this series of changes may be begun independently in different though related sponges.

The spicule is variable. In the common type (fig. 12*a*) there is a short curved axis bearing about 10 rays which are strongylate and larger terminally; total length of spicule 10 μ. Forms differing from the above in having fewer rays, 4–5, also occur (fig. 12 *b*, *c*). The spicule frequently appears as a euaster (fig. 12*d*), but this appearance in many cases (always?) is probably due to the spicule being seen in end view.

(5) Oxyaster (pl. 45, fig. 12*e*). Present in both ectosome and choanosome. Total diameter 14–20 μ; centrum of considerable size; rays long and pointed; often about 9 rays round equator when the spicule is seen more or less in optical section.

(6) Trichodragmas, about 20 by 12 μ; common in ectosome. The dragma, or bundle, is cylindrical; the component rhaphides very fine.

Holotype.—Cat. No. 21302, U.S.N.M.

A related species, *T. columnifer* Stewart is recorded from the Philippines (Sollas, 1888, p. 190). In this species the somal triaenes are orthotriaenes, and the cloacal triaenes are orthotriaenes with one clad much elongated. There is an ectosomal spheraster, minute, with actines reduced to tubercles; a choanosomal chiaster; also orthodragmas (trichodragmas).

The fragments (cloacal tubes), described by Lendenfeld (1906, p. 297) under *T. radiella* Marshall, present in the matter of the skeleton some close resemblance to *T. dubia*. There is a dermal crust of strongylasters, but these spicules appear to be true euasters. The chief megascleres of the tube are orthodiaenes (1906, pl. 27, figs. 1, 2, 4) of the same type as in the *Albatross* sponge. The two species differ greatly in respect to the canalar anatomy of the cloacal tube. It is only the tube of *T. radiella* that is known.

Family GEODIIDAE.

Geodiadae Gray, 1867.
Geodinidae O. Schmidt, 1870.
Geodiidae Sollas, 1888.—Lendenfeld, 1903.
Geodidae Lendenfeld, 1906, p. 305.
Geodidae plus *Erylidae* Lendenfeld, 1910; 1910*b*, p. 267.—Dendy, 1916, pp. 254, 256.

The characteristic microsclere is a sterraster which forms a dense cortical layer. The afferent cortical spaces nearly always, perhaps always, have the character of distinctly differentiated chone canals, which are sometimes uniporal, sometimes cribriporal. Similar efferent chone canals are common, but in their place there are not infrequently present efferent canals of the ordinary tetraxonid type which open by oscula of good size. In a few species the clads of the tetraxon megascleres have degenerated, the triaene thus becoming actually or nearly a tylostyle or style (*Geodinella*). Except in *Geodinella* the tetraxon megascleres are confined to the superficial part of the sponge where they are radially arranged.

Sollas's (1888) subfamilies Erylina (including *Erylus*, *Caminus*, and *Pachymatisma*) and Geodina (including the remaining genera) were discarded by Lendenfeld, 1903, 1906, who divided the family directly into genera. This seems the better practice.

In addition to the genera represented in the collection (*Erylus*, *Geodia*, *Sidonops*, *Geodinella*) the family includes the following:

Pachymatisma Bowerbank (1864, p. 171).

With afferent chone canals the roofs of which are cribriporal. Oscula few, sometimes the apertures of small cloacae; or abundant and scattered; or minute and very numerous. The megasclere-complex includes orthotriaenes and rhabds, but lacks anatriaenes and protriaenes. The sterrasters are spheroidal or ellipsoidal. The other microscleres are microstrongyles which form a dermal layer, and euasters which do not occur at the surface.

Lendenfeld (1903, p. 90 would include in this genus the little known *Stelletta intermedia* O. Schmidt, assigned with a query by

Sollas (1888, p. 241) to *Erylus*. *S. intermedia* has (dermal ?) granulated microxeas 75 µ long.

Caminus O. Schmidt (1862, p. 48).—Sollas (1888, p. 214).—Part Lendenfeld (1903, p. 92).

With afferent chone canals, the roofs of which are cribriporal, and ordinary oscula of good size. The magasclere-complex includes orthotriaenes and rhabds, but lacks anatriaenes and protriaenes. The sterrasters are spheroidal or ellipsoidal, somewhat flattened in some species. The other microscleres are spherules which form a dermal layer, and in some species euasters which do not appear at the surface.

As Topsent (1911, p. 3) remarks, Lendenfeld in his Tetraxonia (1903, p. 92) destroys the homogeneity of *Caminus* by altering the diagnosis so as to include *Geodia megastrella* Carter, in which the dermal (somal in Sollas' terminology) microsclere is a euaster and not a spherule.

In 1910 (p. 221) Lendenfeld gives a definition of *Caminus* in which he says "the dermal microscleres are asters." But this is equivalent to wiping out the useful distinction between asters and spherules, a distinction which is actual even if we admit that spherules are phylogenetically derived from asters.

Isops Sollas (1880, p. 396).—Sollas (1888, p. 236).—Lendenfeld (1903, p. 93).

Skeleton as in *Geodia*, and in habitus and arrangement of orifices not distinguishable from *Geodia*. Incurrent and excurrent cortical canals, both, uniporal chone canals.

In the case of many of the older species enrolled here (Sollas, 1880, Lendenfeld, 1903), it must be understood that the assignment to *Isops* is somewhat provisional, depending on the assumption that the apertures scattered over the surface are the openings of chone canals.

Since Lendenfeld's *Tetraxonia*, species have been described by Topsent (1906 *b*, p. 13); Lendenfeld (1906, pp. 315, 317, 319); Hentschel (1909, p. 365), *I. membranacea*, referred to *Aurora* by Dendy (1916, p. 243).

Caminella Lendenfeld (1894, p. 62).—Lendenfeld (1903, p. 89). In skeleton similar to *Geodia*. With incurrent uniporal chone canals. Instead of excurrent chone canals, there are efferent canals and oscula of the ordinary tetraxonid type.

The genus embodies a definite idea, departing from *Isops* in the character of its excurrent canals.

In Lendenfeld's later definition of the genus (1903) he restricts his statement, as in the case of the other genera of this family, to the excurrent and incurrent orifices, without mentioning the chone canals, whereas the presence or absence of the latter, and the variety of detailed differentiation which they undergo, constitute, as I take it, the really basic features.

Genus ERYLUS Gray (1867).

Erylus Gray, 1867, p. 549.

The afferent orifices are uniporal apertures into chone canals; efferent orifices also the uniporal openings of chone canals, or in other cases larger oscula. The megasclere-complex includes orthotriaenes and rhabds; anatriaenes and protriaenes absent. The sterraster is more or less flattened, often so flattened as to be a thin plate. Microrhabds (here spicules of good size, reaching a length of 70 μ), typically centrotylote, form a dermal layer. Euasters also occur, but not at the surface.

In some species the sterraster passes through an aspidaster stage, a thin plate in which the first formed rays are completely soldered together, thus giving the spicule for the time being smooth surfaces and a smooth margin. The short rays which beset the adult spicule develop secondarily upon the aspidaster stage.

The sequence of changes made in Sollas's definition (1888, p. 209) is as follows:

In none of the recorded species, unless *Stelletta intermedia* O. Schmidt be accepted as an *Erylus* (Sollas, 1888, p. 241), is the sterraster spherical, and Lendenfeld (1903, p. 85) emends by describing the sterraster as "flattened, more or less disklike."

Lendenfeld (1906, p. 305) adds that the sterrasters develop from thin plates ("aus scheibenförmigen Anlagen"). Lendenfeld at the time does not rest this idea on direct observation of ontogenetic stages, but on an examination of the adult sterraster. In *E. polyaster* he finds (p. 306) that the sterraster, which is only moderately flattened, is concentrically stratified, the innermost part appearing as a flattened plate which shows a radial structure, the surrounding layers showing no signs of a radial structure. Lendenfeld regards the inner, central, platelike mass as representing a young stage in the development of the spicule (see also pp. 309–310). This account, which is superseded by Lendenfeld's later one, of the sterraster seems to imply that the spicule develops in a radically different way from that presented in Sollas's scheme (1888, p. LXIV), in which sterrasters in general are derived from spherasterlike stages through growth and continued fusion, from the center outward, of the rays.

Lendenfeld (1910*b*, p. 294) finds that the oscula are sometimes no larger than the afferent apertures, and emends the definition accordingly, saying the genus has "uniporal efferents or larger oscula."

Lendenfeld (1910, p. 17; 1910*b*, p. 267) concludes as a result of his discovery of actual ontogenetic stages that the sterraster of *Erylus* is distinguished not only by its flattened shape but by passing through a stage with perfectly smooth surfaces, which does not occur in the development of the sterraster of *Geodia* and its allies. He therefore separates *Erylus*, designating its sterraster as an aspidaster, from the other Geodiidae, creating for the genus a new family, the Erylidae. The remaining genera are left, "for the present at least, in the Geodidae."

Dendy (1916, p. 256) accepts Lendenfeld's conception of the genus and the family Erylidae. This does not seem to me advisable, for the following reasons:

Erylus is (has been) characterized primarily by its complex of adult spicules. Accepting this idea of the genus, we find that of the 25 species there are only eight (four in Lendenfeld, 1910*b*, two in Dendy, 1916, together with *E. formosus* and *cylindrigerus*, see Sollas 1888 (pp. 213, 240)), in which the sterraster is known to pass through an aspidaster stage. It is by no means safe to assume that the others pass through this stage, for in the species described in this report, *E. cornutus*, they do not.. On the contrary, in this species they develop in the usual way described for sterrasters (Sollas, 1888, p. LXIV). Hence if we follow logically Lendenfeld's proposition we disrupt *Erylus*—namely the group of species, characterized primarily by a certain spicule-complex, and must assign some species, as *E. cornutus*, to another genus and indeed family. I take it, no one would wish to do this. Without minimizing in the least the interest and value of Lendenfeld's new facts, it does not seem to me that they are of such a kind as should influence the definition of genera or families.

Retaining *Erylus* in the older sense, we have to regard, with Sollas, the sterrasters as variable not only in facial outline but in thickness: in some species, very thin; in other species, comparatively thick. When the sterraster is very thin, its mode of growth leads through an aspidaster stage; but such spicules are not radically different from other sterrasters, and detailed study will probably result in the discovery of intermediate modes of development.

This interpretation of the aspidaster as representing only an extreme in a graduated series of morphogenetic methods, leading up from that practiced in *Geodia*, receives support from the recorded details. Thus Sollas (1888, p. 213) who regards the narrow, elongated, flattened, sterraster of *E. formosus* as only a modification of the spherical type, describes for this species a developmental stage made up of a center and trichite-like rays, already of unequal length in different regions (pl. 28, fig. 30), such that the shape of the spicule is thereby determined. This stage which is clearly only a modification of the corresponding one, with equal rays, in the formation of a spherical sterraster, is followed just before the completion of the spicule by a smooth stage (pl. 28, fig. 12), on which "the small spines which granulate the surface" of the adult subsequently appear.

These commence at the extremities and their formation progresses toward the center of each face. A central area on one face, corresponding to the depressed hilum of the more ordinary type of sterraster, remains devoid of spines. The detailed relation of the small spines, developing upon the smooth (aspidaster) stage, to the original rays which determine the general shape of the spicule, has not been worked out by Sollas or his successors. Possibly there is no direct relation, but it is also possible that the small spines are primarily serrations of the original rays.

Again in *E. discophorus* Sollas (1888, p. 238) describes the sterrasters as disciform bodies in which the actines form radiating ridges on the flat faces; the faces being granulated. In *E. cylindrigerus* Sollas (1888, p. 240) says "the young forms of the sterraster present themselves as excessively thin, smooth disks, composed of trichital actines, radiating in a single plane."

Lendenfeld (1910*b*, p. 283) described in detail the aspidasters of *E. sollasii.* They are disciform plates longer than wide; on one face, a smooth, very shallow depression corresponding to the hilum of the *Geodia* sterraster; on both faces and at the margin, short rays like those of the sterraster. The center of the aspidaster is granular, and from it numerous radial lines extend toward the margin. The youngest aspidasters observed (p. 285) were small "oval disks" composed of numerous rays, radiating predominantly (exclusively?) in the horizontal plane from a granular centrum; rays at first isolated, but becoming united basally as they grow in length and thickness. The fusion of rays, owing to their increase in thickness, finally becomes complete, the spicule acquiring a smooth margin and smooth faces. "Their smoothness in this stage constitutes the chief difference between them and the sterrasters of *Geodia.*" "Later small, spine-like protuberances make their appearance on the surface of the smooth young aspidaster. These develop into the protruding rays" of the adult spicule. (See also pp. 272, 306–307.)

ERYLUS CORNUTUS, new species.

Plate 37, fig. 8; plate 45, figs. 5, 16; plate 46, figs. 1, 2.

A large fragment, from station D5275, 80 by 70 by 60 mm., no doubt belonging to a cup-like form with a shallow cloacal cavity. One surface of the fragment is concave and bears apertures, oscula, ½ to 1 mm. in diameter, 3–5 mm. apart. This probably represents the cloacal wall. The remaining natural surface of the specimen, I take it, represents the outer surface of the sponge. In its lower region this surface presents no visible apertures. In its upper region it presents small apertures ½ mm. and less in diameter, scattered sparsely. These are doubtless the pores.

Surface glabrous. Cortical layer whitish brown in color, interior darker. Interior shows many canals, the larger 5–8 mm. in diameter and abundant small ones 1–1½ mm. diameter.

The cortex is about 1 mm. thick, occupied almost exclusively by the sterrasters. The ectochrote is represented only by a very thin dermal membrane, and the innermost, fibrous, layer of the cortex is also quite thin.

The chones are relatively simple structures in this species. The uniporal incurrent chone-canals (pl. 45, fig. 16, *i. ch. c.*) are wide, straight, subcylindrical tubes that pass radially through the whole cortex, each opening below into a larger subcortical canal (*s. c.*). The aperture into the latter is much narrower than the chone-canal in general and is guarded by a fibrous sphincter (*sph.*). Above, the chone-canal is closed in by an area of sterraster-free dermal membrane, full of microrhabds, perforated by the pore (*p.*). A representative incurrent chone gives the following measurements: Pore, 350 μ in diameter; rim of sterraster-free dermal membrane surrounding the pore, 85–180 μ wide; diameter of chone-canal, 850 μ; diameter of aperture into subcortical canal, 525 μ.

The oscula are the apertures of uniporal excurrent chone-canals, essentially similar to the incurrent canals although somewhat wider. The sphincter at the inner end of the excurrent chone, guarding the aperture into the subcortical canal, is possibly narrower on the average than in the case of the incurrent chone. A representative excurrent chone gives the following measurements: Osculum, 1 mm. in diameter; rim of sterraster-free membrane surrounding it, 100 μ wide; diameter of chone-canal, 1,450 μ; diameter of aperture connecting with subcortical canal, 1,150 μ. The sphincter of this chone is therefore 150 μ wide.

There are some slender skeletal tracts, composed of monaxon megascleres, in the interior. Some of these are continuous with the radial bundles of the periphery of the sponge. The radial bundles, each consisting of a triaene with numerous monaxon megascleres, pass to the cortex which they do not enter. They are abundant, often 600–1,200 μ apart, as seen in sections.

Spicules.—1. Orthotriaene (pl. 46, fig. 1). Rhabdome, straight or nearly so, in a radial bundle. Cladome tangential, just beneath the cortex. The clads may be nearly straight, but are usually somewhat curved or bent like a horn, often conspicuously so; the end of a curved clad always pointing inward. One of the clads is occasionally dichotomous. Rhabdome and clads not far from the same size, ½ mm. long, 50 μ thick at the base. The rhabdome is sometimes a little longer than the clad, and the clads of a spicule may differ somewhat in length.

2. Strongyle. Stout, smooth, slightly curved; diminishing slightly in size toward the ends; 700–1,750 μ long, 30–40 μ thick. Most abundant spicule in the skeletal bundles.

3. Oxea. Smooth, 500–1,200 μ long, 12–25 μ thick. Common in the skeletal bundles.

4. Sterraster (pl. 46, fig. 2), Ellipsoidal; distinctly but not greatly flattened; 220 μ long, 175 μ wide, 112 μ thick. The individual rays of the adult spicule are small. In surface views (end views of rays) they appear as minute polygons, with 3 to 5 sharp angles, 2–3 μ in diameter; as a rule so closely set that the intervening spaces appear as lines which form a network; some of the rays farther apart.

The sterrasters in this sponge are thick as compared with those of most *Erylus* species, but in some specimens of *E. lendenfeldi* Sollas (see Lendenfeld, 1903, p. 85; Dendy, 1916, p. 257, says they are "much flattened"), *E. topsenti* Lendenfeld (Lendenfeld, 1903, p. 87), and in *E. polyaster* Lendenfeld (1906, p. 306), the ratio of thickness to the other dimensions is about the same as in *E. cornutus*.

There seems to be no essential difference in the structure or development of the sterraster between this species of *Erylus* and a *Geodia*. All stages in the development of the spicule are abundant in the interior. They are all spheraster-like—that is, consist of a center with rays, the rays gradually fusing as they elongate. No very flat rays and no smooth stage (aspidaster) are to be seen. Stages 30, 50, 70, 80, 100, 120, 140, 200 μ in diameter were measured. They all conform to Sollas' scheme of the development of the sterraster (1888 p. lxiv).

5. Microrhabd (pl. 45, fig. 5, *a*). Straight, or sometimes a little curved, usually centrotylote, but very slightly so; diminishing in thickness toward the ends, which are rounded; 25–50 μ long, about 6 μ thick. Abundant in the dermal membrane; present but rather scanty in the walls of the chone-canals.

6. Strongylaster (pl. 45, fig. 5, *b*). Rays stout, short, and truncated; ends as a rule rounded, instead of being squarely truncated, frequently notched in an irregular way. Total diameter 20–28 μ, number of rays 5–7. Abundant throughout choanosome, especially in the canal walls.

Holotype.—Cat. No. 21262, U.S.N.M.

Genus GEODIA Lamarck (1815), emend. Lendenfeld (1894).

Geodia Lamarck, part plus *Cydonium* Flemming, Sollas 1888.

Geodia Lamarck, emend. Lendenfeld, 1894, p. 46.—Lendenfeld, 1903, p. 104.—Part Dendy, 1916, p. 254.

Both afferent and efferent cortical canal spaces are typically independent chone-canals, the roofs of which are cribriporal. Frequently those portions of the chone-canals, both afferent and efferent, which lie in the extra-sterrastral layer of the ectosome (ectochrote) are so expanded as to have the character of ordinary subdermal spaces which largely fill the ectochrote. In addition to orthotriaenes (or dichotriaenes) and rhabds, the megasclere-complex frequently includes anatriaenes and protriaenes. The sterraster is spheroidal or ellipsoidal, in some species somewhat flattened. The dermal microsclere is a euaster. Other forms of euaster occur in the interior.

Cydonium Flemming is by general consent merged in *Geodia* (Lendenfeld, 1894; Topsent, 1904, p. 68; Dendy, 1905, p. 84; Thiele, 1905). Sollas in his definition of *Cydonium* (1888, p. 218) says the oscula are sometimes the uniporal openings of excurrent chones. But the species records scarcely bear out this statement, since in *Geodia* (*Cydonium*) *mülleri*, the only form cited by Sollas as possibly having uniporal efferent chones, Lendenfeld finds (1894, 1903) the oscula are cribriporal. Whatever species exist with uniporal efferents would be referable to *Sidonops*, while the *Cydonium* forms with cribriporal efferent chones are not distinguishable from *Geodia*.

In some species of *Geodia* the incurrent and excurrent orifices are not distinguishable. In other species the former are somewhat larger. The excurrent orifices are typically grouped in one or more restricted areas, the incurrent orifices covering the rest of the surface. In caliculate forms the chief excurrent area is the surface of the cloaca, but depressed areas on the outer surface may also be excurrent (*G. mülleri*). In some species the two classes of orifices are on opposite surfaces of the noncaliculate body (*G. exigua* Thiele).

The form is massive; or more or less caliculate; sometimes lobose; sometimes a thick, massive incrustation. In some of the caliculate forms, massive young stages are known (*G. mülleri*). Lendenfeld (1894, p. 91) has shown that the caliculate forms can not be separated from the noncaliculate, and hence that Sollas's definition (1888, p. 244) must be altered.

In some species (*G. stellata* Lendenfeld, *G. robusta* Lendenfeld, 1906) the system of subdermal spaces which largely fill the ectochrote is divided into unit systems, each unit system representing the outer (ectochrotal) horizontally expanded and branched portion of a chone-canal. Every unit system is covered over by a special pore area (incurrent or excurrent), and connects at its center with one of the straight tubular endochonal canals which pass radially through the sterrastral and innermost layers of the cortex. In other species (*G. philippinensis*) the system of subdermal spaces is perhaps not divisible into unit systems, since the dermal membrane is uniformly perforated instead of being divided into discrete pore areas and intervening aporous tracts; moreover the subdermal spaces appear to be so interconnected as to form a single, continuous system, connecting at intervals with the endochonal canals.

In some species there are deviations from the type, in the matter of the ectochrotal canal system, which tend toward a secondary acquisition of larger efferent canals and simple oscula. In *G. megastrella* (see Topsent, 1911*b*) for instance, there is a cloaca into which open numerous efferent canals, varying in diameter, each roofed over by a fenestrated membrane. Some of these canals in the neighborhood of the cloacal wall fuse, the common space (larger efferent canal) so formed being roofed over by a large fenestrated area of the cloacal lining. It is not recorded whether excurrent tubular endochonal canals are present in this species. The sterrastral layer, Topsent finds, is practically absent from the cloacal wall. A second step in the same direction, complementary of the above, is made by *G. perarmata* in which Dendy (1905) finds that the cribriform membrane lining the cloaca includes here and there larger openings "where the pores have apparently become confluent and thus formed small vents."

The species such as *Geodia barretti* Bowerbank (Sollas, 1888, p. 250), with uniporal excurrent chones, are referable to *Sidonops* (Lendenfeld, 1903, p. 101). Some later species with simple sphinctrate oscula, *G. micropunctata* Row (1911, p. 296) for instance, are likewise referable to *Sidonops*. In the case of a number of older species assigned to *Geodia* in Sollas' monograph the records leave it in doubt whether excurrent chones exist. The oscula in such forms are described as simple or the implication is that they are simple, and it is quite possible that the efferent canals are of the ordinary type common in tetraxonida. Several of these species have been referred tc *Sidonops* by Lendenfeld (1903), and, unless a special genus is made for them, this seems to me the best procedure.

Dendy has recently discussed the limits of *Geodia*. He has doubts (1916, p. 254) as to the value of the character and arrangement of the incurrent and excurrent orifices for the discrimination of Geodid genera, a set of points on which Sollas and later writers have laid stress. He therefore uses *Geodia* in a wider sense than is customary, his definition of the genus, relating only to the skeleton, covering *Geodia* (plus *Cydonium*) *sens. str.*, *Isops* Sollas, *Sidonops* Sollas, and *Caminella* Lendenfeld.

The common practice is, it seems to me, still the better one. Probably the genera intergrade, but the extreme types are well marked, and many sponge genera intergrade with respect to any one of the several points that go to make up our conception of a genus. As to the biological value of such differences in the canal system, who knows? Perhaps they are quite as hereditary as many skeletal features. At any rate, even if the genera so based are artificial, they are to-day useful categories.

Since Lendenfeld's *Tetraxonia* (1903), species assigned to *Geodia* have been described by Topsent, 1904 (p. 70); Dendy, 1905 (p. 85); Lendenfeld, 1906 (pp. 328, 333); Hentschel, 1909 (p. 366); Lendenfeld, 1910 (pp. 55, 79, 96, 113, 151, 155, 161, 170, 175, 181, 188); Row, 1911 (p. 296); Hentschel, 1912 (p. 314); Lebwohl, 1914 (pp. 42, 49, 57); Stephens, 1915 (pp. 431, 432); Dendy, 1916 (p. 254).

GEODIA PHILIPPINENSIS, new species.

Plate 37, fig. 9; plate 46, figs. 3, 4, 5.

Station? Locality label missing. A very large vase-shaped sponge, 540 mm. high; mouth of vase 450 by 400 mm.; wall at the top 20 mm. thick, growing thicker below. The vase narrows toward the base, having the shape of a truncated, inverted cone; the base itself somewhat expanded, having a diameter of 300 mm.

The outer surface bears conspicuous radial tufts of spicules, about 10 mm. apart. Such tufts are 5 mm. and more in height, 2–3 mm. in diameter at the base, tapering toward the free end. Over a large part of the surface they are broken or worn off. Very many of the spicules composing the tufts are broken at their outer ends; the unbroken spicules are protriaenes with clads 50–70 μ long and anatriaenes with clads 50–70 μ long.. There is some indication that the outer surface, which now is in general smooth, is naturally covered with a continuous but rather thin furze of similar protriaenes and anatriaenes. At any rate, this surface shows such spicules, projecting 3–4 mm., in some spots which have apparently been protected from wear.

The basal surface, surface of attachment, is not quite flat, but is made somewhat uneven by elevations and depressions. It, too, shows in spots a sparse furze of projecting protriaenes and anatriaenes, like that just mentioned. The cloacal surface is smooth, that is, shows no projecting spicules.

Color of the surface is whitish gray, varying to a light brown. Color of choanosome a chocolate brown.

The cortex is slightly under 2 mm. in thickness, the extra-sterrastral layer (ectochrote) about 0.5 mm. thick, but this layer has in places been rubbed off.

The dermal membrane and cortical canal system of the two faces of the sponge, outer and cloacal, are alike. Doubtless the outer is the afferent (pore) face; the cloacal, the efferent or oscular face.

The dermal membrane, on both surfaces of the sponge, is a finely fenestrated membrane in which "pore areas," in the usual sense, are nonexistent—that is, the whole membrane is uniformly porous, and is not divided up into perforated areas and intervening aporous tracts. When it sinks down, as in a dried sponge, on the underlying ectosomal trabeculae, the effect of "pore areas" is produced, that is the ectosomal trabeculae now constitute low and apparently aporous ridges between which lie depressed areas that are obviously porous. But examination of surface preparations shows that there are pores (presumably afferent on one surface, efferent on the other) everywhere, both over the ridges and in the depressed areas. These pores are about 40 µ in diameter, separated only by narrow bands full of asters. They pierce the thin dermal membrane, opening into the subdermal spaces which fill the ectochrote.

The subdermal spaces open below into cylindrical endochonal canals which pass radially through the sterrastral layer. These canals are about 200 µ in diameter, and 1.5–2 mm. apart.

The subdermal spaces doubtless represent the expanded and ramified outer (ectochrotal) parts of independent cribriporal chone-canals, such as occur in some species. It is a question, in this species, whether these spaces are all continuous with one another, thus constituting a single system, or whether the whole set of spaces is divided, as in some forms described by Lendenfeld (1906, *G. stellata*, etc.), into unit systems, each unit system representing the outer part of a single chonal canal, which still connects at its center with the inner (endochonal) part of the same canal. (See under *Geodia.*)

The fact that the dermal membrane is everywhere perforated by closely set pores speaks against the idea that the subdermal cavities are grouped in unit systems, for if pores are everywhere, so must be subdermal spaces. The subdermal spaces within the limits of an ectosomal trabecula (see above) are doubtless very small.

The shape and arrangement of the subdermal cavities can best be directly studied in sections vertical to the surface, and in views of the under surface of the ectochrote, when the latter is cut free from the rest of the cortex. In sections they appear as rounded spaces. In the flat preparations of the ectochrote they appear as irregularly polygonal spaces, 175–500 µ in diameter, separated by thin partitions 50-100 µ thick. In the partitions here and there lie the radial skeletal bundles which as seen in this way are commonly 100–350 µ apart. There is no evidence of the grouping of the subdermal cavities in unit systems. Nevertheless the specimen is a dried one (although the drying was carefully carried out) and this detail of anatomy can not therefore be definitely decided.

The interior of the sponge wall is filled with very abundant large (somal) oxeas, scattered in all directions, often in tracts. In the peripheral region of the choanosome this diffuse skeleton gives place to radially arranged megascleres grouped, though often vaguely, in bundles. Here the somal oxea is again the most abundant spicule, but there are also numerous dichotriaenes and some anatriaenes, the cladomes of the triaene forms lying just below the cortex. Other dichotriaenes, accompanied by anatriaenes and a few protriaenes. along with an occasional large oxea, pass radially through the sterrastral layer of the cortex, constituting the very distinct radial bundles of the cortex, which are of course best seen in the ectochrote. A typical radial bundle in this region includes one or a few dichotriaenes, the cladomes of which support the dermal membrane, accompanied by a good many anatriaenes. and rather rarely by a protriaene or two. Occasionally a large oxea forms the axis of a bundle, instead of a dichotriaene. The radial bundles of the ectochrote are 100–350 μ apart. The skeleton of the cortex and peripheral choanosome is the same on the two surfaces of the sponge.

Spicules.—1. Dichotriaene (pl. 46, figs. 3, 5). Rhabdome 3–4 mm. long, 70 μ thick near cladome; protoclad 100 μ long; deuteroclads 150 μ long; measurements are for the superficial or dermal spicules. The cladomes of some spread out paratangentially just below the sterrastral layer; these are somewhat smaller than the superficial ones. The cladomes of others lie in and support the dermal membrane, dividing it up into imperfectly separated areas, which lack uniformity. The rhabdome of a superficial dichotriaene lies of course in an ectosomal partition (trabecula), and a clad may lie within the limits of a partition. Most of the clads extend out however into the thin sheets of membrane between the partitions. Even here sometimes pores can be seen directly over a clad, indicating that between the clad and the surface there are minute cavities.

2. Somal oxea, 3 mm. long, 50 μ thick; smooth, tapering, usually slightly curved; occasionally taking the shape of a style (strongyloxea).

3. Anatriaenes of the radial bundles (pl. 46, fig. 3). Rhabdome 3 mm. long, 16 μ thick below cladome, clads 70–80 μ long.

4. Protriaenes of the radial bundles (pl. 46, fig. 3). Rhabdome 2–3.5 mm. long, 8–24 μ thick: clads 40–90 μ long. The cladome sometimes has four rays, these of unequal length. The large protriaenes sometimes seen in the interior are probably stages in the development of the dichotriaene.

5. Ectosomal oxea (pl. 46, fig. 3), 370–500 by 6–8 μ. Smooth, evenly tapering; straight or slightly curved. Perforating, and slightly projecting from, the dermal membrane radially or obliquely, or tangential in it; singly or in loose sheaves; abundant. Abundant also in the peripheral choanosome.

6. Sterraster (pl. 46, fig. 3). A flattened ellipsoid: face 124 by 104 μ; thickness 80 μ. Sterrastral layer of cortex about 1.2–1.5 mm. thick. Abundant sterrasters scattered through choanosome.

In the adult sterraster, the outer ends of the rays are stellate—viz. polygonal and very distinctly produced at the angles into sharp little processes (spines of Sollas); the outer ends about 4 μ. in greatest diameter and closely set. Hilum, a depression, as usual showing no rays. Young stages of the sterraster are plentiful in the choanosome. They show that the ontogenetic development of the spicule takes place in the usual way (Sollas, 1888, p. LXIV).

7. Dermal oxyaster (pl. 46, fig. 4, *a*); total diameter 4–6 μ. With a perceptible centrum; number of rays rather small, about five seen in optical section. Very abundant in the dermal membrane of both surfaces. Abundant also in the ectochrote and through the choanosome.

8. Choanosomal oxyaster (pl. 46, fig. 4, *b*). Total diameter, 24–36 μ. Rays long, strong, tapering, more or less distinctly, though minutely, spinose at the end. The spicule is sometimes classifiable as an acanthtylaster of Lendenfeld, but again the rays are really pointed at the end. Total number of rays 6 or 7 to about 20, 5–10 visible when the equator of spicule is focussed. Centrum absent in spicules with smallest number of rays; distinctly developed in spicules with largest number of rays. Size of the spicule is, as usual, inversely as the number of rays. Abundant in the choanosome.

Holotype.—Cat. No. 21320, U.S.N.M.

GEODIA SPARSA, new species.

Plate 37, fig. 5; plate 46, figs. 7, 8.

A fragmentary specimen, from station D5593, chiefly consisting of two subcylindrical branches, largely fused together, but projecting at the top as free and somewhat flattened lobes rounded terminally. Total height 70 mm., greatest width 40 mm., diameter of the branches from 15 to 25 mm.

Color of surface and cortex, pale reddish; that of choanosome a light yellowish brown. The cortex is 1.5–2 mm. thick, and is occupied almost entirely by the sterrastral layer. The choanosome is excavated by numerous canals, 2–3 mm. in diameter, extending more or less lengthwise through the branches.

The surface is now, in general, glabrous. But in protected places there are spicules that project 1–3 mm. These, in such places, are abundant, yet not abundant enough to constitute a spicule-fur.

The dermal membrane with its crust of minute oxyasters is intact, but there are no apertures visible to the eye. The only apertures are minute pores, about 16 μ. in diameter, scattered over the general surface; not anatomically distinguishable into afferent and efferent, although some are doubtless of the one kind, some of the other.

Doubtless most of the apertures are closed, but there is a sufficient number of open ones to show with some certainty the specific arrangement. The following data bear upon the specific arrangement.

The surface shows irregular, meandering, interconnected tracts, immediately below which sterrasters are absent (pl. 46, fig. 8). It is in such tracts, which quite lack definite boundaries, that the open pores are found. These are either well apart, in which case doubtless most of them are simply closed; or they are close together, separated by about the width, or by less than the width, of a pore. The latter condition perhaps shows the natural state of the surface, when the sponge is expanded and the pores are all open. At any rate, the open pores and groups of open pores are scattered in such a wide and general way as to indicate that possibly the dermal membrane is uniformly perforated (or rather perforable) with pores, that is, that there are no well defined pore areas and aporous tracts.

Vertical sections show that the sterraster-free areas just referred to (fig. 2) are largely occupied by subdermal cavities of some size. The thin dermal membrane roofing over these is pierced by the pores, which thus open directly into the cavities. Such a region of subdermal cavities connects below with endochones. Laterally such a region fades away into a thin ectochrote, which over the bulk of the sterrastral layer consists, in the actual specimen, of only the thin aster bearing, dermal membrane.

Endochonal canals of the usual type, narrow radial canals about 250 μ in diameter, perforate the sterrastral layer. The contracted inner ends of the chones form dense, subconical, little masses projecting into the subcortical spaces; scattered over the inner face of the cortex, 1–2 mm. apart. The contracted inner ends of the chones are to be seen in vertical sections and in ordinary flat preparations; their distribution over the inner face of the cortex can also very conveniently be studied in dried pieces from which the choanosome has been picked away.

The megascleres have the usual arrangement. There are oxeas abundantly scattered through the choanosome. In the periphery of the choanosome are numerous radial bundles, some of the megascleres of which enter and even pass through the cortex. The cladomes of the plagiotriaenes, for instance, are characteristically in the ectochrote.

Spicules.—1. Oxea, 2.5–3.5 mm. long, 44–48 μ thick, with many smaller sizes; in the radial bundles and scattered in the choanosome. A long, slender type, 20 μ thick and less, occurs among the spicules which conspicuously project from the surface.

2. Plagiotriaene (pl. 46, figs. 7*a*, 8). Rhabdome long, 50 μ thick near cladome; clads 175 μ by 50 μ. Smaller ones with clads down

to 125 μ long occur. The inclination of the clads away from the orthotriaene state is not great in this spicule.

The plagiotriaenes occur in the radial bundles. They are not at all abundant although their presence is constant. The cladome is at the surface of the sponge or sometimes within the sterrastral layer. In flat preparations the cladomes appear rather scantily strewn over the surface.

Quite small ones, with rhabdome only 20 μ thick and cladi 40–70 μ long, occur scantily in the choanosome, the cladomes lying in the subcortical zone. These are doubtless young stages.

3. Anatriaene. Rhabdome long, 8–15 μ thick above; clads 25–50 μ long; cladome rather shallow. Projecting radially from the surface. A large proportion of the spicules that project conspicuously (several millimeters) beyond the surface are anatriaenes. What are doubtless young stages occur scantily in two positions: (*a*) cladome in the subcortical zone; rhabdome 4 μ thick, clads 7–14 μ long; (*b*) cladome among the projecting ectosomal oxeas: rhabdome 2 μ thick above, clads only 4 μ long.

4. Protriaene. Rhabdome long, 15–20 μ thick above, clads 50–70 μ long. The rhabdome is occasionally prolonged beyond the insertion of the clads, the spicule becoming, in Lendenfeld's terminology, a promesotriaene (pl. 46, fig. 7*b*). The protriaenes occur scantily among the spicules projecting beyond the surface.

5. Ectosomal and subcortical oxeas; 210 by 4–7 μ; piercing and projecting more or less radially from the dermal membrane; here abundant, the spicules disposed singly or in loose sheaves. The same spicule occurs sparsely in the subcortical zone, usually in a radial position.

6. Sterraster. Slightly flattened, thickness about five-sevenths greatest diameter; in face view varying from nearly circular to elliptical: dimensions as seen in face view, 144 by 136 μ (approximately circular) to 193 by 155 μ (elliptical). The circular shape, in face view, may possibly be reached, but a number of measurements showed a discrepancy between the two horizontal axes. In face view the shape is sometimes slightly oval instead of elliptical.

The layer of sterrasters occupies nearly the whole thickness of the cortex, 1.5–2 mm. thick. The spicules are also scattered, together with young stages, through the choanosome. The development is of the usual type.

7. Dermal oxyaster; 4 μ in diameter; with relatively large centrum and short conical rays. Very abundant in dermal membrane.

8. Oxyaster of subcortical zone; also lining the lower part of endochonal canal. Total diameter 24–40 μ. Centrum distinctly developed. Rays long, tapering, spinose at extreme end, the end of the

spine sometimes appearing as an enlargement. Rays are numerous, often about 10 seen at one focus.

9. Oxyaster of choanosome: abundant, with no, or only a very small, centrum; total diameter 32–40 µ, ray length 12–16 µ; number of rays commonly 9–12. Rays relatively long, spinose at extreme end; the outstanding spines together with the apex of the ray making a small terminal crown, about as in Lendenfeld's acanthtylaster (Lendenfeld, 1906, p. 289). The terminal crown is more evident in the larger spicules but is perhaps always present.

The above is the dominant and characteristic aster of the choanosome, but other asters occur here ranging over to the form with large centrum and numerous rays. Smaller oxyasters of all sizes, down to spicules with a diameter of 4 µ, also occur in the choanosome. These have relatively long, sharp rays, and are probably stages in the development of the larger spicules.

Holotype.—Cat. No. 21267, U.S.N.M.

GEODIA JAPONICA (Sollas), var. SPHERULIFERA, new variety.

Plate 38, fig. 1.

Cydonium japonica SOLLAS, 1888 p. 256.

Geodia japonica (Sollas) THIELE, 1898, p. 7.—LENDENFELD, 1903, p. 111; 1910, pp. 72, 235.

A specimen sufficiently close to *G. japonica* to be best listed as a new variety was taken at station D5355. The body is a circular cake-shaped mass with convex upper surface bearing in its center a large shallow depression or cloaca. Horizontal diameter 100–110 mm., vertical thickness 40–60 mm.; cloaca 35 by 25 mm. wide, and about 15 mm. deep. Sponge firm, even hard, compact. Color, whitish brown.

Surface in general now glabrous, although there are in places megascleres projecting a few millimeters. The whole surface is covered with a dermal membrane, uniformly perforated with closely set pores; where this has been rubbed off, the chone canals open on the surface (artefact). The chone canals are distributed throughout the whole cortex and are alike everywhere; each expands above into a saucer-shaped subdermal cavity (chone vestibule). Very generally over the surface the roofs of such cavities are depressed, perhaps a contraction effect, while between them the trabeculae of sponge tissue, covered likewise by the porous dermal membrane, form low ridges. Thus a reticular appearance visible to the eye is produced, in which the depressed areas are a fraction of a millimeter in diameter and the intervening trabeculae have about same width. In flat surface preparations the chone vestibules give a star-shaped appearance, as in Lendenfeld's figure of *G. stellata* (1906, p. 37, fig. 1), owing to the small subdermal spaces which surround and open into the central space. Adjacent chone vestibules are interconnected by these small spaces, which lie in the trabecular regions.

The chief radial megasclere is the orthotriaene; rhabdome 2.5–3.5 mm. long, greatest thickness 70 μ; clads 200–260 μ long, basal thickness 50 μ.

Oxeas measuring 2 mm. by 35 μ, together with smaller ones, are common in the radial bundles and very numerous in the interior where they cross in all directions. The radial cortical oxeas are closely set, project a short distance, and measure 200–300 by 6 μ. Among the large projecting megascleres are some fusiform oxeas 2.8 mm. by 100 μ; these are probably foreign.

Anatriaenes are fairly abundant among the radial spicules, cladome rather deep in the mature spicule, clads 50–100 μ long and strong, rhabdome 5–7 mm. long and 15–30 μ thick. These spicules occur also among the megascleres which project beyond the surface.

Protriaenes with clads 70–100 μ long, occasionally up to 150 μ long with rhabdome several millimeters long and 18–30 μ thick, occur among the projecting megascleres. Promesotriaenes, in general similar to the protriaenes, also occur here; the mesoclad of same length as the other clads or somewhat longer, reaching 210 μ in length.

Sterrastral crust 900–1000 μ thick. Innermost layer of cortex fibrous. Sterrasters are flattened spheroids almost circular in full face view, 80–85 μ in horizontal diameter, 70 μ thick.

Minute strongylasters, 4–6 μ in diameter, form a dermal crust and are common in ectosome and interior. Centrum about one third the total diameter, with 7–8 rays that taper toward the end.

Cortical spherasters, 24–32 μ in diameter, especially abundant in the extra-sterrastral layer of the cortex, also elsewhere in the ectosome and in interior. Rays very numerous, exceedingly short, larger at the base, truncated and rounded terminally.

Polyactinal oxyspherasters, 16–20 μ in diameter, occur in the deeper ectosome and in interior. Centrum about one third the total diameter; rays numerous, tapering.

The oxyasters of the choanosome have 6–7 long tapering, minutely spinulate rays, blunt terminally; centrum absent, rays 20–32 μ long, total diameter of spicule 44–60 μ.

Holotype.—Cat. No. 21266, U.S.N.M.

Geodia japonica has been hitherto described only from Japan. The type reaches a large size, 0.5 meter in diameter (Thiele), is usually vasiform or saucer-shaped but may be massive; outer surface chacteristically lobose. Where the canals open directly on the surface (Lendenfeld, 1910, p. 72), the dermal membrane has doubtless been rubbed off.

Protriaenes and pro-mesotriaenes are listed by Lendenfeld, not by Sollas and Thiele; probably rubbed off in the latter specimens. The anatriaenes vary in details of shape (cf. figs. of Thiele and Lendenfeld); an outward curvature of the clads is pronounced in Lendenfeld's specimen. Minute dermal anatriaenes, some reduced, are inconstant in the species; present in Lendenfeld's specimen (Lendenfeld, 1910, p. 73).

There is some inconstancy (variation) in the type with respect to the microscleres. Thus the oxyspherasters listed by Sollas and Lendenfeld are not recorded by Thiele. The choanosomal oxyaster varies a good deal in size; total diameter in Sollas's type 21–36 μ (Lendenfeld, 1910, p. 77); somewhat smaller in Thiele's specimens; in Lendenfeld's specimen along with reduction of rays to 3–4 the total diameter rises to 46 μ. The minute strongylaster has a tendency to be irregular (Thiele, Lendenfeld).

The variety which I make is especially characterized by the presence of the cortical spherasters, which are not recorded for the type. The choanosomal oxyasters are larger than in the type. In the minute strongylasters the rays are fewer than in the type and relatively longer, the centrum correspondingly smaller.

Genus SIDONOPS Sollas (1889).

Sidonops Sollas, 1889, p. 277.—Lendenfeld, 1903, p. 99.
Synops Vosmaer plus *Geodia* Lamarck part, Sollas, 1888, pp. 227, 244.

In skeleton, habitus, and arrangement of orifices, not differing from *Geodia.* With incurrent cribriporal chones not different from those of *Geodia.* With excurrent uniporal chones, or with ordinary efferent canals that open by simple oscula.

For the group of forms with incurrent cribriporal and excurrent uniporal chones, Sollas in 1888 (p. 227) used *Synops* Vosmaer. But the pores of *Synops* are simple instead of cribriporal. Sollas therefore (1889) renamed his group of forms, *Sidonops. Synops* Vosmaer is regarded as synonymous with, and is merged in, the earlier *Isops* Sollas.

Lendenfeld, 1903, includes under *Sidonops* a number of species, listed by Sollas and other authors under *Geodia*, in which the species records leave it uncertain whether excurrent chone-canals are present. The oscula in these species (*Geodia flemingii*, *tuberculosa*, *reticulata*, *aerolata*, *media*) are said to be simple, scattered, or grouped. It is possible that some of them are the apertures of excurrent chones, or on the other hand only the openings of efferent canals of the ordinary tetraxonid type. I have explicitly indicated, in the genus definition, the existence of this group of species. If excurrent chones are really absent in this group, it might well be made into a new genus, bearing the same relation to *Sidonops* as *Caminella* does to *Isops*. Possibly some of the more recent species fall in this group. In *S. oxyastra* Lendenfeld (1910, p. 40) for instance, Lendenfeld's figure (pl. 7, fig. 2) suggests that perhaps the uniporal excurrent canals are not chone-canals.

The typical chones, incurrent and excurrent, are beautifully illustrated in *S. bicolor* Lendenfeld (1910, p. 48, pl. 9, figs. 15, 16). In some other species, *S. oxyastra* Lendenfeld (1910, p. 41), *S. angulata* Lendenfeld (1910, p. 26), the afferent cortical canals are differentiated into well-marked subdermal spaces and endochonal canals as in *Geodia stellata* Lendenfeld, etc.

Since Lendenfeld's Tetraxonia (1903) species of *Sidonops* have been described by Lendenfeld, 1910 (pp. 18, 24, 40, 46); Hentschel, 1912 (p. 315); Stephens, 1915*b* (p. 18).

SIDONOPS MICROSPINOSA, new species.

Plate 38, fig. 2; plate 46, figs. 6, 9, 10; plate 47, figs. 1, 2, 3, 8.

A specimen from Station D5593. Sponge vase-shaped, tapering below to an attached base; cavity of the vase occupies the whole of the upper surface and is very shallow. Sponge 90 mm. high, 75 mm. wide above, 45 mm. wide at the base; cloacal cavity about 15 mm. deep.

Sponge is brown, dense, and heavy; the cortex somewhat lighter in color than the interior. All canals are small. Both outer and cloacal surfaces are smooth, without projecting spicules; outer surface somewhat uneven.

The outer surface of the sponge is closely dotted with pore areas (pl. 46, figs. 6, 9; pl. 47, fig. 1), 180–360 μ in diameter and about 0.25 mm. apart. These areas which are rounded and plainly visible to the eye, are cortical areas without sterrasters but with abundant dermal spherasters. A pore area may include as many as six pores, but very often the number is only two or three, and frequently the area has only a single pore. The open pores measure up to 70 μ in diameter. Many, however, are much smaller, doubtless nearly closed, and in many areas the pores are completely closed. From the pores of an area pore canals (pl. 46, fig. 9, *p. c.*), in general oblique, pass into a radial afferent chone canal (*r. a. c.*). The inner end of the chone (*ch. c.*) projects into a subcortical crypt (*s. c.*). Round the open pores the spherasters are densely grouped, and they also line the pore canals. When the pore or pore canal is closed, its position is marked by a dense group or a streak, respectively, of spherasters. The radial chone-canal is lined with oxyasters.

The small number of pores in many areas and the fact that some areas have but one pore, make it clear that this sponge closely approaches *Isops.* The same condition has been noted by Sollas for *S. nitida* (Sollas, 1888, p. 231).

The surface of the cloacal cavity is covered with oscular areas, each including a single osculum (pl. 46, fig. 10; pl. 47, figs. 2, 3). An oscular area, like a pore area, is a cortical region without sterrasters but with abundant dermal spherasters. The areas are rounded or irregular, 350 µ to 1 mm. in longest diameter. Each area is the depressed center of a low circular elevation of the general cortex, the periosculiar elevation (pl. 46, fig. 10, *p. o. e.*). The periosculiar elevations are conspicuous to the eye, 1.5–2 mm. in diameter, with some smaller ones, and 1–2 mm. apart. The open oscula reach 200 µ in diameter, but even these are doubtless partially closed. Many oscula are completely closed. The osculum is the aperture of a radial efferent chone-canal (*r. e. c.*), the inner end of the chone, (*ch. e.*), projecting into a subcortical cavity (crypt), (*s. c.*). The open osculum is surrounded by a dense aggregation of dermal spherasters and these line the uppermost part of the chone-canal. When the osculum and canal are closed, the spherasters mark the site (pl. 46, fig. 10, *o*). The main part of the efferent chone-canal is lined with oxyasters. The similarity of the oscular area as a whole to a uniporal pore area is obvious. The difference is that the oscular area is larger and is surrounded by the periosculiar elevation.

The skeleton includes closely set radial skeletal bundles made up of orthotriaenes and oxeas. Throughout the interior of the sponge there are abundant oxeas, scattered irregularly, separately and in tracts.

Spicules.—1. Oxea. A stouter form 1250 by 30 µ, and a slenderer form 1000 by 14 µ, are both common in the radial bundles and interior. Smaller sizes of the two types are abundant and the types of course intergrade. The spicule is smooth, the points not very sharp.

2. Orthotriaene. Rhabdome about 1 mm. long, 35–40 µ thick, tapering to a rounded point. Clads commonly about 220 µ long, 24–28 µ thick at the base. But forms with shorter stouter clads, about 170 by 35 µ, occur. Young stages plentiful.

3. Sterraster, a somewhat flattened ellipsoid, 56 by 48 by 40 µ. The sterraster crust is 230–280 µ thick. Stages in development of the spicule freely scattered through the interior. They show that the development takes place in the usual way (Sollas, 1888, p. LXIV).

4. Spheraster (pl. 47, fig. 8, *a*), 6–8 µ in diameter. Rays numerous but reduced to very low prickles, the centrum making up most of the spicule. The rays are so short that with low powers the spicule appears as a sphere. Abundant in dermal membrane; extending down into the pore and oscular canals, partly (fully half-

way) through the sterrastral layer. Scattered scantily through choanosome.

5. Oxyaster. (*a*) Small form (pl. 47, fig. 8, *b*) about 8 μ total diameter. Centrum well developed. Rays slender, fairly numerous: ray length about one-third diameter of the whole spicule. Common in ectosome and choanosome; lining cortical canals, except in the uppermost part of canal. (*b*) Larger form (pl. 47, fig. 8, *c*), 16–28 μ total diameter. Rays frequently about 12 in number, long and slender, in the larger spicules roughened. Centrum small. Common in choanosome. The two types intergrade, as indeed do the spherasters and the small oxyasters.

Holotype.—Cat. No. 21295, U.S.N.M.

Genus GEODINELLA Lendenfeld (1903).

Geodinella LENDENFELD, 1903, p. 117; 1910, p. 205.

With reduced triaenes arranged radially in the periphery of the sponge and occurring also in the interior. Clads of triaenes reduced to two or one or none, the spicule appearing as diaene, monaene, or style (tylostyle); even when present the clads are degenerate in size, often very degenerate.

The genus was established for *Geodia? cylindrica* Thiele (1898) from Sagami Bay, Japan. Lendenfeld in his first definition (1903, p. 117) described it as a genus in which the triaenes lie in the interior, arranged in longitudinal bundles constituting an axial skeleton; with spheroidal or ellipsoidal sterrasters; and in which the dermal microsclere is an elongated euaster, somewhat streptasterlike. With the discovery of a second species, Lendenfeld found it necessary to emphasize points other than those which he had first picked out. His second diagnosis reads: "Without regular triaenes. The tetraxon megascleres are monaene or diaene teloclads with reduced clads, and occur not only in the superficial part of the sponge but also in the interior."

GEODINELLA SPHERASTROSA, new species.

Plate 38, fig. 3; plate 47, figs. 4, 5, 6, 7.

A fragmentary specimen from station D5312, apparently about one-half of a sponge that was more or less spheroidal or thick cushion-shaped, with a horizontal diameter of about 37 mm. What I interpret as the upper and the latero-inferior surfaces have different curvatures and are separated by a margin which is rounded and vague (pl. 38, fig. 3, right). The upper surface (pl. 38, fig. 3, left) bears low rounded oscular elevations, 2.5 mm. in diameter, each pierced with a central, very small, osculum; the largest of the oscula 0.5 mm. in diameter; interval between neighboring oscular elevations

1–3 mm. The latero-inferior surface bears no oscular elevations. It is the pore surface and is marked by intercommunicating shallow depressions, 2–3 mm. apart and about 1 mm. wide, which divide it up into irregular and only very slightly prominent areas.

The cortex is whitish, the interior darker, gray-brown and compact. The cortex is about 1.8 mm. thick and is occupied almost entirely by the sterrastral layer. The ectochrote over the bulk of the sterrastral layer, except in fact in the sterraster-free areas, is represented only by a very thin dermal membrane.

The pores lie in small and irregular sterraster-free areas abundantly scattered over the latero-inferior surface of the sponge (pl. 47, fig. 6, *p. a.*). The smaller areas measure about 200 μ in diameter; the larger ones are several times that size. The areas are vaguely defined and by no means always sharply separated; the appearances are as if the sterrasters had been shifted about a good deal after the closure of the pores. Sometimes only one pore occupies an area; larger areas include several pores. The pores are mostly closed. There are some open ones, however, and these are about 100 μ in diameter.

The cortex of the latero-inferior surface is traversed by radial afferent chone-canals about 200 μ in diameter, each surrounded by some collenchyma. Into the outer end of each there open a few smaller oblique canals leading from the surface of the sponge. It is into these doubtless that the pores open, and the actual connection could be made out in a few cases. The afferent chone-canals are 2–3 mm. apart and end below, each, in a small endochone. The endochones are contracted, appearing as conical masses of densely fibrous tissue, with the included canal closed. They are much smaller than the corresponding structures of the efferent system (pl. 47, fig. 7). The apex of the chone projects into a subcortical canal.

My data make it clear that the sponge is to be classed among those with cribriporal afferents.

The oscula are the uniporal apertures of radial efferent chone-canals (pl. 47, fig. 7, *ef. c. c.*) The chone-canal from the surface of the sponge to the lower limit of the sterrastral layer is open, although somewhat constricted at several levels; the diameter varying from 200 to 400 μ. Round it is some finely fibrous collenchyma that is evidently contractile. At the lower level of the sterrastral layer, the chonal canal passes in the usual way into its very narrow innermost part, which occupies the axis of the endochone. This part of the canal is closed but is marked out by a streak of asters. The endochone has the usual character, being a conical densely fibrous mass, the apex (*ch. e.*) of which projects into a subcortical canal.

The megasclere skeleton has the arrangement that is usual in the family—that is, the peripheral choanosome is occupied by numerous radially placed megascleres and by bundles of the same, and there are megascleres abundantly scattered, some in tracts, through the interior. Some of the peripheral radial bundles are prolonged for a considerable distance into the interior, but there is no central, or axial, skeletal aggregation comparable to that occurring in *Geodinelle cylindrica* Thiele. An axial aggregation of megascleres (reduced triaenes and rhabds), but a very loose one, occurs also in the other recorded species of the genus, *G. robusta* (Lendenfeld, 1910, p. 208).

The reduced triaene is a constant and abundant constituent of the peripheral radial skeleton, also of the tracts and scattered skeleton of the interior. The dominant megasclere of the interior is the large oxea; and this spicule is abundant also in the peripheral radial skeleton.

Spicules.—1. Reduced triaene, represented by a monaene with degenerate clad or by a subtylostyle or style (pl. 47, fig. 4); about 2 mm. long, 40–44 μ thick.

The distal (cladal) end of the spicule is generally enlarged, but only slightly so, sometimes not at all enlarged (fig. 4*h*). In general there are no signs of clads, not even a branching of the axial canal at the distal end (fig. 4*g*). Nevertheless spicules not infrequently occur in which an extremely vestigial clad is present, monaene condition (figs. 4 *a*, *b*, *c*, *d*, *e*, *f*). The clad may be only a rounded protuberance on one side of the head, or a pointed and more definite protuberance. The axial canal of the clad is not straight, and looks as if made up of a row of dots, which probably means that the canal has not a uniform diameter. The proximal end of the reduced triaene is pointed.

In the peripheral part of the sponge the reduced triaenes lie in the usual position occupied by triaenes in this family. The spicule as a whole (rhabdome) is radial, and the distal end is commonly just below the sterrastral layer, sometimes in the layer.

2. Oxea, 2.4–3 mm. by 48 μ; in peripheral radial skeleton and in interior.

3. A long slender oxea, about 12 μ thick; not quite straight; occurring in some abundance in the radial skeleton, often in sheaves; along with the stouter megascleres or separately from them; sometimes, perhaps always, passing entirely through the cortex and projecting beyond the surface.

4. Sterraster, ellipsoidal and somewhat flattened; 200 μ long, 164 μ wide, 130 μ thick. Ends of rays small, stellate, leaving the usual reticulum of lines between them. Sterrastral layer about 1800 μ thick; the spicules together with developmental stages also scattered in the choanosome. Developmental stages plentiful, showing that the spicule develops in the usual way.

5. Dermal spheraster (pl. 47, fig. 5, *a*), 8 μ in diameter; abundant on pore and oscular surfaces, and extending for a short distance into the cortical canals. Centrum large, somewhat irregular; rays short, tapering to points that are not sharp; ray length considerably less than diameter of centrum; number of rays rather numerous often about 7–8 when seen at equatorial focus.

6. Strongylaster of cortical canals (pl. 47, fig. 5, b); lining the cortical canals and in the surrounding collenchyma. Centrum is smaller, rays longer and more numerous than in the dermal spheraster. With an immersion objective, rays are seen to be roughened, viz. most minutely spinose, terminally. Total diameter of spicule 12–14 μ; ray length equal to or somewhat greater than diameter of centrum.

7. Oxyaster (pl. 47, fig. 5, *c*), 30–32 μ in diameter; abundant throughout choanosome. Centrum small, 4 μ or less in diameter, or none; rays long, slender, tapering; rays few in number, 7–10. With an immersion it may be seen that the rays are roughened in the outer half, the roughnesses increasing in size towards the end of the ray, which is therefore often not strictly pointed. The spicule makes an approach to the acanthtylaster of Lendenfeld, but only a very slight approach.

Holotype.—Cat. No. 21268, U.S.N.M.

This species is certainly very close to *Geodinella robusta* Lendenfeld from the Pacific coast of North America (1910 p. 205), and possibly should be, and with the study of more specimens may be, best described as a variety of that sponge. In Lendenfeld's species, based on four specimens assigned to three varieties, the cortical efferent canals are uniporal, the cortical afferent canals probably cribriporal. The canal system, as in the *Albatross* specimen, is thus not different from that of *Sidonops.* Most of the reduced triaenes are monaenes, but diaenes occur in one variety; in one variety the clad of the monaene has a considerable length. Besides these and oxeas, strongyles and tylotes occur. Styles or subtylostyles also occur. Lendenfeld does not recognize these latter as reduced triaenes, but my data establish this origin for *G. spherastrosa* and make it probable for his species as well. As to the microscleres the choanosomal asters are oxyasters scarcely differing from those of the *Albatross* sponge. The dermal microscleres are, however, strongylasters, instead of spherasters with tapering pointed rays. The strongylaster of *G. robusta* is obviously the same spicule that occurs in the cortical canals of the *Albatross* form. The tangible points of difference between the two forms are, then, the character of the dermal aster and the greater degree of degeneration of the triaene in *G. spherastrosa.*

Suborder HADROMERINA.

Hadromerina Topsent, 1898 plus.

Sponge body generally compact and massive, approaching a definite shape, sometimes lamellate; also incrusting. Megascleres all monaxonid, often radially or somewhat radially arranged. In a few forms (Chondrosidae) the megascleres have been lost. Skeleton rarely fibrous, not distinctly reticulate, and usually without spongin. Microscleres, if present, are asters of some form, including under this term astrose spicules which develop from monaxon primordia with which chelae are associated in a few species. Probably derived for the most part from the Astrophora through loss of the tetractinellid megascleres but possibly polyphyletic.

Thiele (1898) and Dendy (1905, p. 106) pointed out that Topsent's sections, Aciculida and Clavulida, could not be retained since the characteristic megasclere in some of the Aciculida was in reality monactinal and not diactinal. In *Donatia*, for example, and in *Tuberella*, the so-called strongyloxea does not differ from a style. The sections are therefore abandoned and the group is divided at once into families.

For definitions and synonymy of the genera, in general, Topsent, 1898, is of the first importance. For the earlier history of many genera Vosmaer, 1887, is indispensable. Dendy, 1921*b*, lays emphasis on the distinction between true asters (euasters) and "pseudasters" (microscleres which develop from monaxon primordia) and transfers several families (Spirastrellidae, Clionidae, Suberitidae, Polymastidae) to the immediate neighborhood of the Desmacidonidae, which he would regard as the parent family. (See Spirastrellidae). He further restricts the group by deleting the Epipolasidae, referring these genera largely to the Stellettidae (1916, pp. 225, 235; 1916*b*, p. 93).

I have not been able to consult the original and so do not attempt to distribute *Kowalewskyella* and *Protosuberites*, new genera by Svarchevskii. (See Zoological Record for 1905.)

Family EPIPOLASIDAE.

Epipolasidae Sollas, 1888.

Coppatiidae Topsent, 1898, p. 108 plus *Streptasteridae* Topsent, 1898, p. 109.

With oxeate magascleres and typically with astrose microscleres, but the latter may be lost (*Spongosorites*, *Topsentia*). The asters may be all euasters or euasters associated with sanidasters (*Asteropus*) or all streptasters (inclusive of sanidasters), with which microrhabds or trichodragmas may be associated.

Dendy (1905, p. 107) combined Topsent's two families, and has been followed by Hentschel (1909, 1912) and Stephens (1915*b*).

More recently (1916, 1916*b*) Dendy would merge these forms, which are generally recognized as reduced Astrophora, in the Stellettidae, possibly some of them in the Pachastrellidae (Theneidae of this report). In this, I prefer not to follow him.

In addition to the genera represented in the collection, *Asteropus*, *Jaspis* (plus *Coppatias*), and *Spongosorites*, the family includes the following: *Amphius* Sollas, 1888, *Cryptotethya* Dendy, 1905, *Diastra* Row, 1911 (merged by Dendy, 1916, in *Aurora*), *Topsentia* Berg, 1899 (for *Anisoxya* Topsent, see Topsent, 1900, p. 2), *Trachycladus* Carter, 1879, *Raphidistia* Carter, 1878, *Spiroxya* Topsent, 1896 (emended 1900), *Holoxea* Topsent, 1892, *Melophlus* Thiele, 1899. Topsent, 1919, moves *Hemiasterella* Carter (syn. *Epallax* Sollas, 1888, *Kalastrella* Kirkpatrick, 1903), transferring it to the Axinellidae alongside of *Adreus* Gray and *Vibulinus* Gray (see Astraxinellidae); Dendy (1921*b*, p. 144) places the genus in the Spirastrellidae.

Rhabdastrella Thiele (1903, p. 934) is merged in *Jaspis*. By Dendy, 1916, this genus is merged in *Aurora*.

Magog Sollas (1888) has been deleted. (See Dendy, 1916.)

Dorypleres Sollas (1888) is merged in *Jaspis*. (See discussion in Lindgren, 1898; Topsent, 1898; Thiele, 1900, p. 58).

Astropeplus Sollas (1888) is merged in *Jaspis*. (See Topsent, 1898; Dendy, 1916.)

Genus ASTEROPUS Sollas (1888).

Asteropus SOLLAS, 1888, p. 205.

With diactinal magascleres (oxeas). Microscleres include both euasters (oxyasters) and sanidasters.

ASTEROPUS SIMPLEX (Carter).

Plate 38, fig. 4.

Stellettinopsis simplex CARTER, 1879, p. 349.
Asteropus simplex SOLLAS, 1888, p. 205.

A specimen from Station D5179.

The skeleton would not differentiate this sponge from the type, but in form of body it differs from specimens hitherto collected. It may then be designated forma *pyriformis*.

Asteropus simplex (syn. *A. haeckeli* Dendy), the only species of the genus, has been recorded from Australia and Ceylon (see Sollas, 1888; Dendy, 1905; Hentschel, 1909); from the Indian Ocean (Dendy, 1916); from Okhamadal in Kattiawar (Dendy, 1916*b*). Carter also records the species from Haiti. (See Dendy, 1905, p. 110; 1916, p. 252.) The shape as hitherto recorded is massive, sometimes attached; or amorphous, or incrusting.

The *Albatross* specimen is of an elongate pear shape, tapering below to a conical base, which was perhaps rooted in the sand. There is no surface of attachment. The upper end of the sponge has been cut away, the actual upper end of the specimen showing four canals, each about 1.5 mm. in diameter, close together and descending vertically into the sponge. The specimen is 50 mm. high, with a greatest width of 18 mm.; width of exposed upper surface 10 mm.

Color, light brown, darker at the lower end. The ectosomal layer, 1.5 to 2 mm. thick, is colorless.

Surface finely hirsute with projecting spicules, some of them protruding 1–2 mm. The upper part of the sponge, more than half the whole body, is completely covered with an incrusting *Gellius* about 2 mm. thick. Dendy's specimen from the Indian Ocean (1916, p. 251) was similarly incrusted with a *Gelliodes*, and Hentschel (1909, p. 370) records that some of his specimens from the southwest coast of Australia were covered with an incrusting *Hymedesmia*.

- The following data on the skeletal arrangement may be given. The choanosome is thickly filled with the megascleres which are both scattered and in loose tracts, the latter predominantly longitudinal. The ectosomal layer contains fewer megascleres than the choanosome. Some cross it in tracts running more or less radially to the surface. There are also abundant tangential megascleres just below and supporting the dermal membrane. These average a smaller size than the spicules of the interior. The small oxeas, about 160 μ long, of the incrusting *Gellius* have penetrated in abundance the dermal membrane of the *Asteropus*, lying both on and in it.

Spicules.—1. Oxea 2,500–3,100 by 85–100 μ, with many smaller sizes down to spicules about 700 μ long.

Sollas (1888) puts the size at 1,320 by 28 μ. Dendy records for one specimen (1905) a maximum size of 1,900 by 65 μ; for another (1916) 2,100 by 65 μ; for another (1916*b*) 1,700 by 70 μ. Hentschel (1909) records a maximum of 2,525 by 72 μ.

2. Oxyaster, abundant in the choanosome; a few in the ectosome. Total diameter 40–70 μ; no centrum; rays commonly 5–7 in number; rays slender and tapering, roughened, but barely so, in the distal portion. The spicule sometimes, especially in canal walls, may closely imitate the small pentacts of the hexactinellida.

The size and distribution of this spicule are subject to considerable variation in the species. Thus in Hentschel's specimens (1909) the diameter ranges from 17 to 48 μ, and the spicule is much more abundant in some than in other specimens. In Dendy's specimens the diameter varies from 30 to 50 μ; the spicule "scarce and easily overlooked" in one specimen (1905); spicule local in distribution, so as to be easily overlooked, in another (1916*b*).

3. Sanidaster. Abundant in dermal membrane and in walls of some of the ectosomal canals; present scantily here and there in the

choanosome. Total length 12–20 μ, commonly about 16 μ. Spicule varies in details of shape.

Holotype.—Cat. No. 21252, U.S.N.M.

Dendy has raised the question (1916*b*, p. 99) whether this widely distributed species is indeed really a species or only a collection of forms which happen to agree in spiculation, because in different localities related sponges (possibly species of *Ancorina*) have undergone a similar reduction of skeleton. The same reflection is appropriate to many others of our literature species. A first essential to the answer is a detailed, intimate, knowledge of the structure and development as observed in different localities. A part of the value of systematic zoology, as it seems to me, is to indicate critical cases which are well worth such intensive study.

Genus JASPIS Gray (1867).

Jaspis Gray, 1867, p. 526, plus *Coppatias* Sollas, 1888, p. 206, plus *Dorypleres* Sollas, 1888, p. 426, plus *Rhabdastrella* Thiele, 1903, p. 934.

With diactinal (oxeate) megascleres. Microscleres are euasters. The body may be lamellate or cyathiform, or a cake-shaped mass, or massive and variously shaped, or incrusting. The oscula are small, numerous, and scattered; the pores and oscula in some forms on opposite faces. The megascleres are intercrossed in all directions without order (*Jaspis*, *Dorypleres*), or arranged partly in radiating fibers, partly scattered (*Coppatias*). In some species the megascleres of the ectosome are smaller than those of the choanosome, and are sometimes designated microxeas. They lie in a predominantly tangential direction and may constitute a well marked ectosomal skeleton. The microscleres are especially abundant at the surface.

Topsent (1898, p. 107) pointed out that *Dorypleres* Sollas could not be distinguished from *Coppatias* Sollas.

Lindgren (1898, p. 357) and Thiele (1900, p. 58) would retain *Jaspis* Gray (syn. *Dorypleres* Sollas) for forms in which the megascleres are scattered without order and *Coppatias* Sollas for those in which they are combined, partially at least, in tracts. Topsent (1904, p. 128) would also follow this practice. But the distinction made between these two groups of species is scarcely practicable, and of the two names Dendy (1916, p. 252) shows that the rules of nomenclature demand *Jaspis* for the combined group of forms.

Thiele (1903, p. 934) handles the generic idea, suggesting subdivision of the genus. Nomenclature demands, he thinks, that *Coppatias* be merged in *Jaspis*. The species without small oxeas and with radial tracts of oxeas should be combined in a new genus *Rhabdas-*

trella. Dorypleres might be revived for other species without small oxeas and in which the megascleres are scattered without order. *Jaspis* would be retained for species with small oxeas.

Kirkpatrick (1903, p. 239) includes a species, *J.* (*Coppatias*) *vaculifer* in which the microscleres are not euasters but microstrongyles. These are usually centrotylote and form a compact dermal layer. Kirkpatrick regards them as modified euasters. While this is probably so, the inclusion of the species disturbs further the homogeneity of *Jaspis*, and it would seem better to make it the type of a new genus.

JASPIS SERPENTINA, new species.

Plate 38, fig. 6; plate 47, fig. 11.

A specimen from station D5414.

Sponge essentially lamellate, but rising from an attached base so as to form a shallow more or less circular but irregular cup. Surface, especially that of the cup-cavity, uneven with depressions and thickenings, some of the depressions extending quite through the sponge. The inner surface of the cup is the oscular, the outer surface the pore face of the sponge. Cup 85–100 mm. wide; lamella 7–15 mm. thick. Sponge compact and firm. Color whitish gray.

Plan of the afferent system: Pores, 30–40 μ in diameter, are distributed in small, closely set areas over the outer face of the sponge. The areas are rounded or irregular, and include, often, 3–6 pores or sometimes twice that number. From the pore areas afferent canals pass into the interior. These connect sometimes with tangentially extending spaces lying not far below the surface, but there is no extensive development of subdermal spaces.

Plan of the efferent system: Main canals, about 0.5 mm. in diameter, pass more or less radially and at considerable intervals, from the interior towards the inner surface of the cup-like body. They connect with a peripheral system of spaces, lying about 200 μ below this (the oscular) surface, and large enough to be seen with the eye. From these, short oscular canals, sometimes only the direct prolongations of main efferent canals, proceed to the surface. The oscula are minute, 100–500 μ in diameter, and are scattered abundantly over the inner surface of the cup.

The ectosome of both surfaces is lighter in color than the interior, and something over 0.5 mm. thick. The difference in respect to the canal system between the ectosomal regions of the two surfaces (pore and oscular) of the sponge is easily seen in gross sections.

Spicules.—1. Small oxeas (pl. 47, fig. 11, *b*), sharp-pointed, evenly tapering, very slightly curved; commonly ranging from 60 by 3 to 350 by 8 μ, but reaching a length of 500 μ. The ectosome on both surfaces of the sponge is thickly packed with these spicules, which are arranged tangentially, obliquely, and radially. The spicule is also very abundant in the choanosome.

2. Large twisted rhabds (pl. 47, fig. 11, *a*), sometimes with oxeate, sometimes with strongylate ends; about 2 mm. long, and 40 μ thick at the middle. From the middle the spicule tapers gradually toward both ends, which, as said, are in some spicules sharp, in others rounded. The choanosome is filled with these spicules, so twisted and intertwined as to form a very coherent mass. An abnormal form of the spicule occasionally occurs, in which the axis is branched, bifid or trifid, at one end.

3. Chiasters (pl. 47, fig. 11, *c*), 6–8 μ in diameter, with no (enlarged) centrum and about 7–8 rays; rays cylindrical and minutely spinose distally (acanthtylasters of Lendenfeld). Spicule abundant on both surfaces and throughout the sponge.

4. Oxyasters (47, fig. 11, *d*, *d'*), commonly 20–20 μ in diameter, with no (enlarged) centrum and about 7 strong, sharp rays. They number of rays may be reduced to 5, 4, or even 3 (triad condition). As usual, the forms with fewer rays are the larger, the total diameter sometimes reaching 50 μ with a ray length of 24 μ. Small spicules ranging down to the size of the chiaster occur, doubtless young stages. The oxyasters are abundant throughout the sponge.

The difference between ectosomal and choanosomal skeleton is more conspicuous in this than in other species. The shape of the choanosomal megasclere is also distinctive.

Holotype.—Cat. No. 21270, U. S. N. M.

Genus SPONGOSORITES Topsent (1896).

Spongosorites Topsent 1896, p. 117, 1898, p. 108, and Dendy 1905, p. 182, plus *Acanthoxifer* Dendy 1905, p. 156, plus *Anacanthaea* Row 1911, p. 329.

Form various, sometimes lamellate, in which case the oscula may be on one face, pores on the other. Choanosomal skeleton made up of oxeas, thickly and irregularly strewn. Ectosomal skeleton dense, composed of oxeas usually smaller than the choanosomal spicules, and variously grouped, sometimes in radial brushes, sometimes tangential and forming a smooth crust. Without astrose microscleres, but sometimes with trichodragmas.

SPONGOSORITES SULUENSIS, new species.

Plate 38, fig. 8; plate 48, fig. 3.

Two fragmentary specimens, 6 mm. thick, the larger 80 mm. by 55 mm. in area, both with rounded natural margin, from station D5168.

Dermal membrane of pore surface uniformly perforated with small closely set pores. The main afferent canals extend in radially from this surface, and are imperfectly seen through the dermal membrane causing the appearance of "pore areas." The canals are less than 1 mm. in diameter and 1–2 mm. apart (pl. 48, fig. 3).

The oscula vary in diameter from 2 mm. to less than 1 mm., and are very abundant, commonly about 3 mm. apart. Two or three, occasionally more, oscula may open into a common shallow surface depression, or they may open singly. Round each osculum there is a narrow depressed marginal zone which is perforated by small apertures resembling pores. Where the oscula open into a common depression, the whole floor of this between and around the oscula is porous. The main efferent canals opening at the oscula are radial to the surface and something less than 1 mm. in diameter (pl. 48, fig. 3).

The sponge is comparatively dense and compact, whitish brown in color.

The skeleton of the interior is made up of oxeas of very different sizes, many of them large; thickly and irregularly strewn. Vague tracts of spicules are here and there distinguishable, extending from the interior toward the surface. There is a very little spongin uniting the spicules, best seen in teased preparations on spicules that have been torn apart.

The ectosomal skeleton at each surface of the sponge is distinct, although it shades off into the choanosomal skeleton. At the pore surface are well defined radiating brushes of oxeas, thickly and uniformly distributed, and projecting slightly beyond the surface. The skeleton of this surface also includes multispicular tangential tracts of oxeas, lying between the pores, but these are obscured by the radiating brushes which are about 400 μ long.

The ectosomal skeleton of the oscular surface in general is composed of tangentially placed oxeas. These form a dense, smooth dermal crust about 100 μ thick. The porous areas round the oscula, on the contrary, have the same kind of skeleton as the pore surface of the sponge.

Spicules.—1. Choanosomal oxeas, 140 by 7 to 1,350 by 32 μ, the larger sizes abundant. The spicule is smooth, slightly curved, and tapers gradually from the middle to the points, which are sharp.

2. Ectosomal oxeas similar to those of choanosome, but smaller, ranging from 140 by 7 to 450 by 16 μ. The oxea is not infrequently represented by a style.

3. Trichodragmas, in the choanosome; not very abundant. The exceedingly fine hair-like spicules may occur singly but usually in bundles, about 100 by 2–8 μ, including from 2 or 3 to a considerable number of spicules. The spicules of a bundle are often loose and divergent at the ends. The trichodragmas are frequently curved, sometimes spirally, round two or three of the larger megascleres, as if holding them together. They are best seen in teased preparations.

Holotype.—Cat. No. 21297, U.S.N.M.

The *Albatross* sponge plainly lies in the neighborhood of *Jaspis* (plus *Coppatias*) in the Epipolasidae as a form without astrose microscleres. Closely related sponges without microscleres are the species described by Topsent (1896) and Dendy (1905) under *Spongosorites*. In *Spongosorites*, as emended by Dendy (1905, p. 182), the choanosomal skeleton is composed of oxeas scattered thickly in all directions, the ectosomal skeleton is especially dense and is composed of similar but smaller, tangentially placed, oxeas. Dendy (1905 and 1921*b*), would transfer this genus to the Axinellidae, but I see no good reason for doing so.

Acanthoxifer Dendy (1905, p. 156) is, I take it, also a related sponge. In this genus the main skeleton is a confused reticulation of, chiefly smooth, oxeas; cortical skeleton made up of radial brushes of, chiefly spined, oxeas; microscleres, trichodragmas. *Anacanthaea* Row (1911, p. 329) is a similar form in which none of the oxeas are spined. These two genera are placed by Dendy (1905) and Row (1911) in the subfamily Heteroxyinae Dendy (referred now, Dendy 1921, p. 25, to the Desmacidonidae) created by Dendy for *Acanthoxifer* and for *Heteroxya* Topsent, which he would remove from the Donatiidae. But their place, as well as that of *Spongosorites*, including the *Albatross* species, seems rather to be in the neighborhood of *Jaspis*.

The several genera are certainly close together. In respect to the ectosomal skeleton, the *Albatross* sponge resembles on its oscular face (spicules tangential) *Spongosorites sensu* Dendy, on its pore face (spicules in radial brushes) *Acanthoxifer* and *Anacanthaea*. In the choanosomal skeleton all the forms are essentially alike. It does not seem possible therefore to retain these genera as separate groups. *Spongosorites* may easily be sufficiently enlarged to include the other forms, and the definition of this genus, employed above, represents an attempt to do this. Dendy (1921*b*, pp. 124–126) discusses the genus and describes a new species from the Indian Ocean.

Family DONATIIDAE.

Tethyidae AUTHORS.
Donatiidae BAER, 1906.

Massive, discoidal, or incrusting forms. The megascleres are radially arranged rhabds: styles (=strongyloxeas, sometimes fusiform) or oxeas. Ectosome often but not always differentiated to form a fibrous cortex, frequently furnished with radiating microrhabds. The microscleres exclusive of microrhabds, which are not always present, are euasters, sometimes of two sorts. But microscleres may be entirely absent (*Tuberella*, *Trachya*, *Heteroxya*).

In addition to the genera represented in the collection, *Donatia* and *Tuberella*, the family includes: *Tethyorrhaphis* Lendenfeld (1888), *Xenospongia* Gray (1858), *Trachya* Carter (1870), *Heteroxya* Topsent (1898), and *Halicometes* Topsent (1898). (See Topsent 1920*d*, p. 33.)

For forms with streptasters an *appendix* to the family may be created. *Scolopes* Sollas (1888), with amphiasters instead of euasters, would be classed here. Topsent (1898, p. 108) pointed out that it was nearly related to the Donatiidae.

Topsent (1898) assigns *Xenospongia*, somewhat doubtfully to be sure, to the Spirastrellidae. Dendy (1905) after original study of a good specimen refers it to the Donatiidae.

Dendy (1916, p. 259) is inclined to think that if "epipolasid" forms, such as certain species which he refers to *Aurora* (see *Aurora* under Stellettidae), are admitted into the Stellettidae, then possibly the whole family of Donatiidae should be merged in the Stellettidae. He nevertheless retains the family, although he would limit it, possibly excluding the oxeate forms: *Trachya* and *Heteroxya.*

Thiele's suggestion (1903, p. 965) that the name *Donatia* should be used for *Tethya* Authors and *Tethya* for *Craniella* Authors has been followed by many, Lendenfeld (1903) adopting *Tethya* in the latter sense and Baer (1906) introducing the name Donatiidae for Tethyidae Authors. Dendy (1916 p. 260) reviews the matter and thinks the wisest course would be to abandon the generic name of *Tethya* altogether, since Lamarck included very diverse sponges under this name without indicating any one as the type species. Topsent has recently (1920*b*) made out a good case in equity for the practice that was common before 1903—namely the use of *Tethya* for hadromerine sponges such as *Alcyonium aurantium* Pallas (= *A. lyncurium* Linnaeus)—and it seems to me regrettable that any change was ever made in this custom. Still *Tethya* in such a sense appears to have no valid claim in strict law while *Donatia* has.

Topsent, who (1920*b*) has recently gone through the older literature on this matter, is convinced that *Tethya* can not be used for a sigmatophorous sponge, since *T.* (*Alcyonium*) *cranium* O. F. Müller, included by Lamarck under *Tethya*, is not such a sponge, Johnston (1842, p. 83) being in error when he picked this name for his own sponge which plainly is a sigmatophorous form. For this (sigmatophorous) type Topsent advocates *Craniella* Schmidt (1870), thus upholding the practice of Sollas as against that of Gray, Carter (see Sollas, 1888, p. cxxii), Thiele, and Lendenfeld. Sollas' practice in this matter, adhered to by Topsent (1904, 1920*b*), Dendy (1905), and Kirkpatrick (1908) should, I think, be followed.

Genus DONATIA Nardo (1833).

Donatia Nardo, 1833, p. 522.—Thiele, 1903, p. 965.
Tethya Authors.—Lendenfeld, 1896, p. 16 (older synonymy in detail).

Sponge usually of more or less spheroidal form, but sometimes a flattened crust. Ectosome distinctly differentiated from the choanosome, constituting a cortex which is more or less fibrous and which lacks special microrhabds. Megascleres are rhabds, usually fusiform styles or subtylostyles. Microscleres are spherasters together with smaller euasters of one or two sorts.

DONATIA INGALLI (Bowerbank), var. SEYCHELLENSIS (E. P. Wright).

Plate 47, figs. 9, 10.

Tethea ingalli Bowerbank, 1872, p. 119.
Alemo seychellensis Wright, 1881, p. 13.

The species as here conceived (see below) covers *D. ingalli* (Bowerbank), *D. maza* (Selenka), *D. seychellensis* (Wright), and *D. japonica* Sollas.

A specimen of the variety was taken at station D5181. Sponge is spheroidal, 25 mm. in diameter, considerably incrusted with shelly débris opposite the oscular process.

Over most of the surface the conules are conspicuous conical projections very generally produced into slender gemmiferous processes. The pores form irregular areas between the conules. There is a single osculum at the end of an oscular process, the latter 8 mm. long and 2 mm. wide.

The ectosome is colorless and in general about 2 mm. thick, thinner in the depressed areas and thicker in the conular regions. It is fibrous in its deeper stratum (pl. 47, fig. 9, *f. s*). Its outer stratum is much interrupted with subdermal spaces and pore canals. The choanosome is greenish in color.

There are the usual strong radial bundles (pl. 47, fig. 9) extending from the center, expanding and subdividing in the cortex into narrow brushes which support the dermal membrane. The styles making up the radial bundles taper toward both ends and measure 1,600–2,000 by 28–32 μ.

The styles of the surface brushes range from small ones, 500 by 8–10 μ, up to the larger spicules just mentioned.

In the outer half of the choanosome, between the radial bundles, there are abundant styles more or less radially arranged, those in the immediate neighborhood of the radial bundles inclined obliquely to the latter. The spicules commonly range from 500 by 12 μ to 1,000 by 18 μ, with some larger ones 1,800 by 32 μ.

The central ends of the radial skeletal bundles are bound together by small styles, about 400 by 12 μ, forming a dense aggregation or "nucleus."

The spherasters (pl. 47, fig. 10, *a*) are of the usual type with large centrum and conical rays; total diameter of the spicule about 60 µ. They are abundant in the ectosome, especially just below the level of the subdermal cavities. A few smaller ones occur in the outermost stratum of the choanosome.

The chiasters, tylasters of some writers, acanthtylasters of Lendenfeld (pl. 47, fig. 10, *b*), are about 12 µ in diameter with small centrum and about seven rays which are enlarged and spinose at the end; rays appear simply tylote when seen at magnifications of 400–600. The spicules are crowded at the surface forming a dermal crust; also abundant in the ectosome in general; also abundant in the walls of canals in the choanosome.

Chiasters with terminally spinose rays have long been known to occur in several species. Lindgren (1898, p. 358) refers to this fact. In *D.* (*Stelletta*) *nux* Selenka, the larger ectosomal chiasters are of this kind (Thiele, 1900, p. 61). In *D. lyncurium* Authors such spicules sometimes occur (Topsent, 1900, p. 295). In *D. magna* Kirkpatrick (1903, p. 240) they are characteristic: also in the several varieties of *D. japonica* described by Hentschel (1909, p. 372). Topsent in his recent essay on *Donatia* (1918) shows rays of this character in all the species figured. Doubtless in some of the older descriptions the spinelets have simply been overlooked.

The choanosomal oxyasters (pl. 47, fig. 10, *c*) are common throughout the choanosome, although less abundant than the chiaster. Total diameter of spicule 30–40 µ; rays about 6–7 in number, spicule often hex-radiate; centrum very small, rays long and tapering, straight or curved. The rays sometimes bear a few, one to three, lateral spines, and are not infrequently bifid. Spicules transitional to the chiaster now and then occur; intermediate in size; the rays comparatively stout and bearing at the apex several short spinelets.

The data given above make it plain that the *Albatross* sponge belongs to the type known as *D. seychellensis*.

The difficulty in distinguishing species in *Donatia* has been pointed out more than once. Sollas (1888) recognized *D. lyncurium* (Linnaeus), *D. ingalli* (Bowerbank), *D. maza* (Selenka), *D. seychellensis* (Wright), *D. multifida* Carter, and recorded several other insufficiently described and uncertain species.

The species which Sollas recognized are distinguishable types, whatever their genetic relationship may be and regardless of the fact that various kinds of intermediate forms exist. Their differential characteristics may be stated as follows:

In *D. seychellensis* there are spherasters, chiasters (doubtless characteristically acanthtylasters), and larger choanosomal oxyasters. Cortex with extensive intracortical cavities, and only fibrous in its deeper stratum.

D. ingalli differs from *D. seychellensis* in not having extensive intracortical cavities, but, instead, long narrow canals of uniform diameter each leading from a single pore and passing completely through the cortex. The cortex is fibrous throughout.

D. japonica differs from *D. seychellensis* in the absence of the choanosomal oxyaster. Hentschel (1912, p. 317) finds intermediates. Topsent (1918, p. 599) thinks perhaps Hentschel had representatives of several species before him. But it seems probable now that we shall find, if we look for them, individuals that are intermediate in respect to any one of the differential characters that separate related forms in this and many sponge genera.

D. maza differs from *D. seychellensis* in the form of the choanosomal aster. It is what is often called a strongylaster and distinctly smaller than the oxyaster of *D. seychellensis.* The rays are roughened rather than distinctly spined whereas in *D. seychellensis* they are characteristically spined; rays only rarely dichotomous whereas they are characteristically so in *D. seychellensis.* The spicule of the *Albatross* form (see above) may be said to vary toward the *D. maza* type.

In *D. lyncurium* the cortex is variable, sometimes of the *D. ingalli*, sometimes of the *D. seychellensis* type. Smaller euasters, Topsent, 1918 (p. 568), variable in details of shape but of about same size, the ectosomal not differing from the choanosomal; centrum small; rays 9–15, feebly spinose along their length or only terminally so, the terminal spines frequently producing an enlargement (acanthtylaster type); rays cylindrical or tapering, varying towards the oxyaster type, which apparently is reached or nearly reached (Topsent, 1918, fig. 18, p. 568), although Topsent says "they do not differentiate into pure oxyasters"; diameter of entire spicule 13–20 µ.

In *D. multifida* Carter spicules are essentially like those of *D. seychellensis*, but the body is "membraniform, lacinulate, expanded, flat or erect, fan or vase shaped, proliferous" (Sollas, 1888, p. 441).

Since Sollas' monograph a very considerable number of forms have been described, one effect of which has been to make the distinctions between the species recognized by Sollas less sharp. Besides Sollas, Lindgren, Thiele, Hentschel, Dendy, and recently Topsent (1918) have critically discussed these distinctions and deepened our knowledge of the genus.

Lindgren (1898, p. 358) rearranged and combined the recorded species, reducing the number to three: *D. lyncurium* Authors, with spherasters, and oxyasters 12–20 µ in diameter; *D. ingalli* Bowerbank, with spherasters, tylote chiasters 6–16 µ in diameter, and oxyasters 20–52 µ in diameter; and *D. japonica* Sollas, with spherasters, and tylote chiasters 8–16 µ in diameter. Of these he regarded *D. lyncurium* as the simplest and probably the oldest form. From it he derived *D. ingalli* and from the latter *D. japonica*. This grouping of Lindgren's is open to the criticism (Thiele, 1900, Dendy, 1905, 1916, Hentschel, 1909, 1912) of being artificial, in that the characters of the smaller euasters are exclusively used for the distinguishing of species, although other points of difference between recorded forms are known and again there are recorded forms which, in respect to the astrose characters, are intermediates, falling not in but between Lindgren's species.

Thiele (1900, p. 61) points out that for the secure foundation of the species it is essential to learn how constant within a species is the structure of the cortex.

Dendy in 1905 (p. 113) was inclined to use the well known, widely spread, and manifestly variable form, *D. lyncurium* Authors (Mediterranean, Atlantic, and Arctic Oceans) as a world-wide species, and recorded Ceylon forms under it as varieties. Later (1916, p. 260) he refers these eastern forms to *D. japonica*, *D. ingalli*, and *D. seychellensis*, adding a new species, *D. stella-grandis*, distinguished especially by the very large size of the spherasters.

Hentschel, 1909, would disregard the difference in cortical anatomy recorded for *D. seychellensis* and for *D. ingalli*, merging the former in the latter. Topsent (1897, 1906, 1918) practices this treatment. In 1912 (p. 316) Hentschel decides for a use of the designation *D. ingalli* as covering a group of forms, "species, subspecies, tropi," which it is not at present possible to characterize differentially. Such conclusions state, implicitly at least, a task of systematic zoology that begins to be imperative—namely, the critical study of certain widely spread and variable species, with the purpose of marking out the lines and magnitudes of the variation that affects, in different quarters of the world, the several "characters," setting down also the environmental conditions that are associated with particular character combinations—all, as solid and wide bases for rational experimentation.

Topsent in his comprehensive and very helpful review (1918) of the various forms (34 species and about 10 varieties) classed under *Donatia*, proposes to merge many of them. I am here only concerned with a few of the changes proposed. With regard to others I have formed no opinion. Topsent would unite a number of Sollas's types, *D. ingalli*, *D. maza*, *D. seychellensis*, *D. multifida*, along with several species more recently described, all under the name of *D. diploderma* (Schmidt). In the matter of the name chosen, it seems to me that Schmidt's description of *Tethya diploderma* (1870, p. 52) is too incomplete to enable one to refer, with certainty, specimens of *Donatia* to this species. Schmidt to be sure states (1880, p. 78, footnote) that Selenka's *T. maza* (redescribed, from authentic specimens, by Sollas, 1888) is identical with his

T. diploderma, but there is nothing to show that this statement is more than a conjecture.

If the species enumerated above are to be merged, as I think should be done with perhaps the exception of *D. multifida*, so peculiar in its shape of body, it would be more justifiable to use for the group the name of the oldest recognizable form—namely, that of *D. ingalli* (Bowerbank, 1872), as Hentschel, 1912 (see above) has done. Hentschel in his text (p. 317), although not in his definition, would also include *D. japonica* Sollas, a species which Topsent (1918) holds to be distinct. In regard to the latter three of this set of forms, *D. ingalli*, *maza*, *seychellensis*, and *japonica*, Sollas long ago (1888, p. 428) stated that he was "inclined to regard them as varietal modifications of a single species."

I may be allowed a word or two as to what I understand by this expression "varietal modification" or variety (compare what is said on the separation of genera and subgenera, farther on under *Tetilla*.)

Certainly the phenomena of variation in sponges are coming closer to our eyes as many, myself among the number (1904, 1919, 1919 *b*), have pointed out in recent years. The various diagnostic features which have been picked out as characterizing natural races all vary and vary, apparently, independently of one another, so that many kinds of combinations come into existence. Moreover they do not vary as definite, relatively unalterable, features (unit characters of the older Mendelian terminology) which are present or absent, as in the typical Mendelian crossings, but any one "character" varies quantitatively so as to produce a series only the extremes of which contrast sharply. Hence as the number of combinations known to us increases—in other words, as the number of carefully studied individuals from various regions, intergrading more or less and in very complex fashion, increases—it becomes more and more difficult to apply our customary method of classification, which is essentially a splitting method. Any attempt to cleave the whole of one of these assemblages into subgroups (subspecies, varieties, etc.) is arbitrary. It can only lead to erroneous conceptions. Nevertheless within a group of related natural objects, such as an assemblage of *Donatia* individuals, we see certain distinct types to which numbers of individuals conform, but we also see numerous individuals which conform to none of these and which in respect to one character are intermediate between certain two types while in respect to another character they may be intermediate between two other types. If now we are to express objective fact in our classifications, we have to recognize by name certain somewhat heterogeneous groups (*Donatia* species) and the types within these (varieties), understanding by the latter not subdivisions into which the whole of the group is split. In classifying individual organisms it will thus often happen that the group (species) is the only category we can use, but in other cases the individuals conform to well-marked types and may therefore be referred to varieties. This is the practice which F. E. Schulze years ago marked out as the proper one (1879, pp. 11–12) when dealing with exuberant variability, and, I believe, it is understood by many to be the correct procedure. Nevertheless in systematic manuals of to-day we frequently find a widely ranging and variable species represented as *separable* into subgroups, usually designated subspecies, the implication being not that one is a relatively heterogeneous remainder but that all are equivalent groups stamped with about the same degree of homogeneity.

With regard to a fundamental difference in meaning between terms, such as subspecies and variety, for intraspecific groups, all systematists must confess that our knowledge of variation in sponges (and organisms in general) is yet too fragmentary for us to apply, widely and consistently, in the work of classification the ideally different categories for which such terms are sometimes meant to stand. The increased use in recent years of "subspecies'" has been marked, especially for geographical races, and this has perhaps tended to crystallize the erroneous idea that a species is a congeries of equivalent smaller groups, into some one of which any particular individual must go.

Nor are we as yet able to use, except here and there, in systematics the various kinds of intraspecific groups with which experimental genetics begins to make us acquainted. As to the genetic values and correlations of the differential characters that stamp varietal types we are largely in the dark. This is true, for instance, of the differences in cortical anatomy which mark off *D. ingalli*, *sens str.*, from *D. seychellensis*, as it is true of the absence of a particular microsclere (as in *D. japonica*). Topsent (1918) tends to disregard the features of cortical anatomy. But, as far as I know, there are no recorded data which indicate that they are less constant than spicular features.

Genus TUBERELLA Keller (1880).

Tuberella Keller, 1880, p. 276.

Without a fibrous cortex and without microscleres. Chief megascleres are large fusiform styles arranged in distinct spiculo-fibers that course toward the surface, or which are so abundant that an arrangement in fibers is scarcely perceptible. Small slender styles radiately arranged occur in the ectosome.

TUBERELLA CILIATA, new species.

Plate 39, fig. 1.

A specimen from station D5641.

Sponge massive, amorphous, partially breaking up into rounded lobes. Surface very minutely and thickly conulose, and finely hirsute with spicules that project in general about 1 mm. There is some indication that small oscula, now closed, are scattered sparsely over the surface. Pores closed, but arrangement of subdermal cavities indicates that they are scattered. Color whitish brown.

There is a translucent, gelatinous-looking ectosome about one-half millimeter thick, not fibrous but collenchymatous. The collenchyma extends down into the choanosome, accompanying the larger canals which connect the interior with the ectosomal spaces.

The ectosomal cavities include (1) shallow, interconnecting subdermal spaces about 50 μ deep, immediately below the thin surface membrane, which is only about 4 μ thick; and (2) a system of inner spaces lying close to the choanosome, and from which relatively large canals pass into the interior. The inner ectosomal spaces are commonly about 175 μ deep; they interconnect and are much more conspicuous than the true subdermal spaces. Just beneath the latter the ectosomal cells are elongated parallel to the floor of the space, but there is no distinctly differentiated fibrous stratum.

The body is well filled with very numerous styles, 1,400–2,000 by 20–36 μ; straight, or slightly curved or bent; tapering toward the small, rounded, basal end as well as toward the pointed apex; in the peripheral region curving radially to the surface, the superficial ones projecting in the conuli, a few in each conulus. The spicules are so abundant that there seems at first sight to be no arrangement into fibers, but in a carefully macerated slice in which the spicules remain in position, a very imperfect arrangement into spiculo-fibers can be made out. The fibers, or tracts, are dense, without spongin, close together, and imperfectly separated. They all trend toward the surface.

Very slender ectosomal styles, 1,100–1,300 by 4 μ, about cylindrical in shape, sometimes slightly curved, are abundant. In the ectosome they are radially arranged and grouped indistinctly in bundles, the outer spicules of a bundle projecting from one of the minute conuli. But these tufts of projecting spicules are not far from being continuous with one another.

Holotype.—Cat. No. 21319, U.S.N.M.

This is evidently a quite different form from *T. aaptos* (O. Schmidt), hitherto the only generally recognized species of the genus. In *T. aaptos* (Topsent, 1900, p. 285) the larger megascleres form distinct, well-separated spiculo-fibers which radiate from centers, and the ectosomal styles are much shorter and stouter than in the Philippine species, forming moreover fairly distinct diverging brushes. *T. aaptos* has been recorded from the Mediterranean and Gulf of Mexico (see Topsent, 1900), from Porto Rico (Wilson, 1902, p. 388), southwest Australia (Hentschel, 1909, p. 377), Aru Islands (Hentschel, 1912, p. 319), Okhamandal in Kattiawar (Dendy, 1916*b*, p. 101).

Family SPIRASTRELLIDAE.

Spirastrellidae Ridley and Dendy, 1886, 1887.

Megascleres usually styles or tylostyles, sometimes diactinal. Asters of various forms (euasters, spirasters, sanidasters, discasters) occur, often forming a dermal crust.

The genera are *Timea* Gray, 1867 (=*Hymedesmia* Bowerbank, Authors), *Spirastrella* Schmidt, 1868, *Latrunculia* du Bocage, 1869, *Sceptrintus* Topsent, 1898, *Placospongia* Gray, 1867, *Negombo* Dendy, 1905, *Anthosigmella* Topsent, 1918, and *Diplastrella* Topsent, 1918. *Xenospongia* Gray, placed in this family by Topsent, is removed to the Donatiidae. Dendy, 1921*b* (p. 131), has recently added to the family *Barbozia*, *Didiscus*, and *Sigmosceptrella*, new genera, and also *Sceptrella* O. Schmidt, *Podospongia* du Bocage, *Trachycladus* Carter (see Epipolasidae), and *Axos* Gray (see Vosmaer, 1887, p. 243).

The spiraster of the Spirastrellidae has generally been regarded as a modification of the "true aster" (euaster). But Vosmaer (1909) concluded that this spicule is not an aster but a spiral monaxon with spines, since the latter contain no axial canals as do the actines of a true aster. Dendy (1916*b*, p. 96; 1921*b*, p. 129*ff*) in pursuance of Vosmaer's argument and as a result of the discovery of some fundamentally interesting forms, transfers the Spirastrellidae and along with them the Clionidae, Suberitidae, and Polymastidae to the neighborhood of the Desmacidonidae which he would regard as the parent family. This is a change of great importance, one which demands time for a consideration of all the facts involved. Topsent in a paper published in 1922 goes so far in this direction as to transfer *Latrunculia* and the very similar forms *Podospongia* and *Sigmosceptrella* to the Poeciloscleridae (nearly equivalent to Desmacidonidae), grouping them in a new subfamily, Latrunculiinae. He regards the position of Dendy's other new genera, *Didiscus* and *Barbozia*, as doubtful. Whatever resemblance there is between the special microscleres of the latter two and the former three genera may, he thinks, be attributed to convergent evolution. The remaining Spirastrellidae he would apparently retain as a family in the usual position (as here).

There is not perfect agreement among writers as to the nomenclature of the genera. Thiele, 1903 (p. 955) has ruled that

Hymedesmia Bowerbank in Topsent's sense (1898, 1900) should be designated *Timea* Gray; also that the designation *Hymedesmia* Bowerbank should be used for the ectyonine group of species for which Topsent (1892) proposed the name *Leptosia*, since this group included *Hymedesmia zetlandica* Bowerbank, the type of *Hymedesmia*. Lundbeck (1910, p. 41), Stephens (1912, p. 58; 1915*b*, p. 22) and Hentschel (1912, p. 322) accept Thiele's changes, as do I. *Hymedesmia* in Topsent's sense of 1898 has, however, the sanction of Topsent's later papers and of Dendy, 1905. Dendy 1921*b* (p. 142) now accepts Thiele's changes.

The systematic position of *Placospongia* is discussed by Vosmaer and Vernhout (1902, p. 16). These authors call to mind that Keller (1891) demonstrated that the so-called sterrasters of this genus develop from spirasters, and that he therefor transferred the genus from the neighborhood of the Geodiidae in the *Astrophora* to the Spirastrellidae. Keller's move has been generally followed (Vosmaer, Lendenfeld, Thiele, Dendy).

Genus SPIRASTRELLA O. Schmidt (1868).

Spirastrella Schmidt, 1868, p. 17.

Sponge incrusting, cushion-shaped, massive, or vasiform; in the latter case the two surfaces may be structurally different, the outer incurrent, the cloacal excurrent. Surface of cushion-shaped or massive sponges may bear digitate or less regularly shaped processes, some or all of which bear terminal oscula. Megascleres, tylostyles or styles or intergrades, or a mixture of the two forms. Microscleres usually present, and abundant, in the form of spirasters; frequently forming a dermal crust; sometimes exceedingly scarce or even wanting.

SPIRASTRELLA VAGABUNDA Ridley.

Spirasirella vagabunda Ridley, 1884, p. 468.

Station D5142, three pieces. These have been sliced off from what were evidently large sponges, or perhaps one sponge; the largest slice measures 200 by 120 mm., with a thickness of 40 mm. The elevations on the surface of the sponge are in one piece digitate processes, 20–30 mm. high; in another piece the larger processes are irregular nodules; in the third piece the processes are conical and only about 10 mm. high. The processes contain prolongations of the large canals of the interior, often a single axial canal of good size in a process. Typically, doubtless, this opens by a terminal osculum, but in the actual specimen open oscula are found only on a few processes. The surface of the sponge is glabrous and actually aporous; the pores, like most of the oscula, have doubtless closed. There are numerous large canals in the interior, 3–10 mm. in diameter; some sand is found here and there in the choanosome. Color of sponge brown, the cortex whitish.

The choanosomal skeleton is a feltwork of megascleres aggregated, in part, into dense but vaguely defined spiculo-fibers, between which are abundant spicules; the fibers, or tracts, cross and fuse in irregular fashion; the skeleton as a whole is close (dense); a little spongin here and there cements the spicules together. The megascleres are styles, the head sometimes slightly tylote, 600–700 by 16–20 μ.

The ectosome is occupied by a conspicuous and compact layer, varying in thickness from 0.7 to 3 mm., of megascleres crossing in all directions. The megascleres are like those of the choanosome. This dense "cortex" is traversed by narrow tubular canals, more or less radial to the surface; those in the piece examined were a fraction of a millimeter wide and 2–4 mm. apart.

At the surface are small, radially placed styles (sometimes subtylote), imperfectly arranged bouquet-fashion, the points projecting; these spicules, in places at any rate, are abundant enough to form a continuous stratum; they measure 250–450 by 6–10 μ.

There is the usual dermal crust of spirasters. These are 10–12 μ long; axis long and curved, probably always spirally, the microscopic image showing two or sometimes only one curve; rays numerous, short, stout, blunt, distributed as usual along the length of the axis.

Under *S. vagabunda* Ridley, 1884 (p. 468), described sponges from Torres Straits, Trincomalee, and Ceylon, which were massive, "tending to grow up into large nodular elevations, which may bear one or more vents." The interior is made cavernous by wide canals. There is a strong "cortex," about 0.8 mm. thick, formed by intercrossing megascleres. The megascleres are tylostyles 600 by 20 μ, or (in var. *trincomaliensis*) scarcely tylote at all and about 13 μ thick; spirasters delicate and long, 32 μ long, with fairly numerous short and rather blunt spines. The largest specimen measured 225 mm. by 130 mm., with a thickness of 60 mm. Ridley calls attention to the characteristic and relatively constant external appearance of the species.

Dendy, 1905 (p. 122), extends the idea of the species by describing several varieties from Ceylon. In one variety (*trincomaliensis*), the surface elevations are digitate processes about 23 mm. long, excavated by the exhalent canals, which are "extremely narrow" (sponge was perhaps greatly contracted). The megascleres form some, at any rate, surface brushes. Megascleres are tylostyles and styles about 620 by 9 μ; spirasters 12 μ long, with blunt rays (blunt in all spicules?). In another variety (p. 124) the spirasters may reach a length of 48 μ. Dendy merges several species.

Topsent, 1893, describes a variety from the Gulf of Tadjoura, and (1918) suggests some fusion of species.

Thiele, 1900 (p. 70), assigns sponges from Ternate to this species, into which he would merge *S. inconstans* Dendy (Ceylon).

Dendy, 1916*b* (p. 132), has recently reported the species, var. *tubulodigitata*, from Okhamandal, and 1921*b* (p. 139) (type and varieties) from the Indian Ocean.

Vosmaer, 1911 (p. 14), merges in this species *S. digitata* Hentschel, from Southwest Australia. In *S. digitata* (Hentschel, 1909, p. 385), the sponge body is massive with processes that are digitate, clavate, lobular, or irregularly nodular ("knölliger Gestalt"). Megascleres are subtylostyles varying toward the tylostyle and toward the style, 225–700 by 8–12 µ; there are two classes, large and small, but with intergrades. Spirasters are 12–16 µ long with stout irregular outgrowths which only rarely are spinous in shape. A cortex is not mentioned, nor is the arrangement of the small megascleres stated. The sponges are evidently close to the *Albatross* specimens.

Vosmaer (1911) goes far in combining *Spirastrella* species. He merges (p. 15) *S. vagabunda*, based on the study of Indo-Australian sponges, in *S. angulata* Bowerbank, from Madeira, and this species along with many others he combines under *S. purpurea* (Lamarck).

Topsent, 1906*b* (p. 2), has redescribed the type specimens of *S. purpurea*. The species is probably vasiform, one face (outer) bearing radial tuberosities, the other (inner) without tuberosities and with very numerous punctiform oscula about 1 mm. apart. There is a "cortex" about 0.55 mm. thick; at the surface, a crust of spirasters and radial tylostyles, the points of which just project. Megascleres, tylostyles 330–350 by 10–12 µ. Spirasters vary in size and details of shape; the common large size, 22 µ long.

Topsent, 1918, criticises Vosmaer's fusion of species as too extensive. Hentschel, 1912 (p. 324), and Stephens, 1915 (p. 434), however, make use of *S. purpurea* in the extended sense of Vosmaer, Hentschel recording under this name sponges from the Aru Islands, while Stephens' sponges came from the South Atlantic. I incline to believe with Topsent, 1918, that Vosmaer's species idea is too comprehensive. In particular it seems to be that in the case of the species here recorded (*S. vagabunda*), and in the case of many others, some classificatory importance should be assigned to habits of growth which, under suitable conditions, lead to the assumption of more or less definite external characteristics. Such growth habits are perhaps quite as hereditary as the small details of spicular shape and size.

With respect to the small radially placed megascleres at the surface of the *Albatross* specimens, it must be supposed either that they are of variable occurrence in the species (which would rob *S. vagabunda* of one of its characters and in so far weaken the particular species idea), or that they have been generally overlooked.

Genus PLACOSPONGIA Gray (1867).

Placospongia Gray, 1867, p. 127.—Vosmaer and Vernhout, 1902, p. 16.

Sponge incrusting or branching. There is a cortex composed chiefly of thickly packed sterrospires (pseudo-sterrasters); within this a layer of soft parenchyma; and within this, in the branching type, a solid axis of sterrospires. Surface conspicuously divided into polygonal areas by narrow grooves, destitute of sterrospires, which contain canal apertures. Spicules include parenchymal tylostyles in radiating bundles, smaller cortical tylostyles (varying to styles) projecting in the dermal grooves, sterrospires, spherasters (sometimes rare or absent), dermal spherules or in other species dermal microspires (=microstrongyles or small spirasters or spirulae of Authors). Parenchymal spirasters of good size occur in some species.

PLACOSPONGIA MELOBESIOIDES Gray.

Placospongia melobesioides Gray, 1867, p. 127.

Station D5174, a specimen representing a branch, 60 mm. long, diameter 8–14 mm., color pinkish buff. Station D5108, several fragments, among them one consisting of a vertical branch, 33 mm. high with diameter 8–12 mm., arising from an incrusting portion; all dark red brown.

The following spicular measurements are taken from the specimen collected at D5174. Parenchymal (choanosomal) tylostyles, 600–900 by 12 μ; Hentschel, 1912 (p. 323), gives for the species the range in length as 821–1250 μ. Cortical tylostyles, varying to styles, 190–320 by 10–16 μ, the spicules thus relatively stout; range in length for the species (Hentschel, 1912) 197–509 μ. Sterrospires 60–64 μ long; range for the species 67–78 μ. Spherasters, abundant especially at the surface, 16–18 μ in diameter; range for species as recorded by Hentschel 12–17 μ. Dermal spherules, in the usual abundance, about 1.5 μ in diameter; Hentschel gives range as 1.2–3 μ.

The species has been repeatedly taken in the Malay archipelago and Indian Ocean, and possibly in Florida waters (Sollas, 1888, p. 272). Since the monograph of Vosmaer and Vernhout, it has been recorded by Dendy (1905, p. 126) for Ceylon, and by Hentschel (1912, p. 323) for the Aru Islands. The other well known species of the genus, *P. carinata* (Bowerbank) has been recorded since Vosmaer and Vernhout's memoir, by Dendy 1916*b* (p. 132), 1921*b*, (p. 144); and by Hentschel, 1912 (p. 324).

Family POLYMASTIDAE.

Polymastidae VOSMAER, 1887, p. 328.

Ectosome histologically differentiated into a cortex that is usually distinctly fibrous. A cortical skeleton is also differentiated. The characteristic megascleres are monactinal, tylostyles or styles, and the skeleton is radiate. Ordinarily without microscleres.

In addition to *Trichostemma* (see below), the genera are *Polymastia* Bowerbank, 1864 (syn. *Rinalda*, *Weberella*), *Spinularia* Gray, 1868 (syn. *Rhaphidorus* Topsent, see Stephens, 1915*b*, p. 31), *Proteleia* Ridley and Dendy, 1886 (placed by Lendenfeld, 1906, p. 175, in an appendix to the Sigmatophora as a genus in which one of the megasclere forms still retains a trace of its original tetraxonid character), *Tylexocladus* Topsent, 1898, *Sphaerotylus* Topsent, 1898, *Quasillina* Norman, 1869, *Ridleia* Dendy, 1888, *Tentorium* Vosmaer, 1882, *Atergia* Stephens, 1915*b* (p. 32).

Dendy, 1916*b*, and 1921*b*, continues as formerly to combine the Polymastidae with the Suberitidae, under the latter name. But the family (Polymastidae) is in general use (Topsent, 1904, 1917; Wilson, 1904; Kirkpatrick, 1908; Hentschel, 1914; Stephens, 1912, 1915, 1915*b*).

Genus TRICHOSTEMMA Sars (1872).

Trichostemma SARS, 1872, p. 62.—RIDLEY and DENDY, 1887, p. 216.

Free living sponges of a symmetrical form which approaches the hemispherical; with a marginal fringe of long radiating spicules. Oscula, one or more, on only one face of the body at the ends of short tubes or papillae. There is a thick ectosome so well filled with spicules as to form a relatively dense cortex, which entirely surrounds a much less dense choanosome. Megascleres, tylostyles varying sometimes toward the style. No microscleres.

TRICHOSTEMMA STRATICULATUM, new species.

Plate 38, fig. 7; plate 48, fig. 1.

Ten specimens from station D5428.

Shape of body varying from that of a plano-convex lens to a conical shape. The approximately flat face is the oscular. The marginal fringe projects toward this face. The convex surface is smooth and clean and in one specimen bears a slender projecting process (pl. 48, fig. 1). The oscular face is covered with fine sandy débris. It bears a number, 6–8, of small rounded papillae about 0.5 mm. in height. These are scattered, although in several specimens one papilla is close to the center of the face. The papillae are probably all oscular. At any rate this was found to be the case with several (five) actually sectioned. Pores?

Color of the clean upper surface whitish, the marginal region in most specimens marked off, as a somewhat translucent ring, from a central more opaque region which indicates the extent of the choanosome. Diameter of the body varies from 9 to 20 mm. In a representative lens-shaped specimen, the body diameter is 15 mm., thickness at the center 6 mm. In one of the conical specimens, the diameter is 11 mm., the central thickness 8 mm. The marginal fringe is 6–9 mm. wide.

Probably the body can change its shape to a limited extent. At any rate, the fringe is inclined much more sharply toward the oscular face in some specimens than in others, and the marginal region of the sponge body in some specimens inclines distinctly in that direction.

As to the natural position of the sponge, Ridley and Dendy, 1887 (p. 218), infer that the oscular face is always the upper, and that therefore in one of their two species the fringe spicules project upward, in the other species downward. Vosmaer (1885, pl. 1) represents his sponges as resting on a substratum by means of the spicular fringe, but with the oscula on the upper surface. It is not impossible, however, that in sponges so resting the oscular face may be directed downwards (the position of the animal would then be rather loosely analogous to that of bottom-living medusae such as certain Rhizostomes), in which case my figure (pl. 48, fig. 1) should be turned. In *Halicnemia patera*, Bowerbank (1866, p. 96) regards the oscular face as the under one. In the physiologically somewhat parallel case of the Crinorhiza sponges, Ridley and Dendy think the radiating marginal processes project downward, thus serving to hold up the sponge on a muddy bottom. But Topsent (1902) argues that, at any rate in some Crinorhiza forms, these processes project upward.

On bisecting the sponge it is seen (pl. 48, fig. 1) that the ectosome is colorless and so thick that the loose brown choanosome (*ch*) occupies only about one-third of the central thickness of the sponge. The oscular canals (*o. c.*) are simple tubular canals, 350–500 µ wide leading from the choanosome, through the cortex, each to an osculum. Each canal is immediately surrounded by ascending radial skeletal bundles.

The spicules are fusiform tylostyles that vary in size in the different regions of the body. The head is small but usually well developed, although the spicule not infrequently becomes a subtylostyle.

The cortex of the upper (oscular) face, in respect to its skeleton, is distinctly stratified (pl. 48, fig. 1). (*a*) The superficial stratum, about 600 µ thick, is composed of closely set short tylostyles, about 500 by 12 µ, radially placed and projecting slightly at the surface.

The spicules are in dense conical bouquets, which, however, intermingle close to their apices and form a continuous furze. (*b*) The middle stratum, (*u. c. m.*) is only the space between the superficial and the inner stratum. It includes some scattered tylostyles, 300 by 8 μ to 600 by 16 μ. (*c*) The inner stratum is somewhat thicker than the superficial one, and is not so compact. It is composed of tylostyles radiating obliquely in all directions from points near the choanosomal border. A vague grouping in brushes is perceptible in some spots. A common size of spicule is about 600 by 16 μ. The spicules as a class are certainly thicker and probably somewhat longer than those of the superficial stratum.

The cortex of the lower (convex) face is also made up of three strata. (*a*) The superficial stratum is not very compact. It is composed of obliquely radial tylostyles, not in brushes, many projecting slightly. The prevailing trend is from the center toward the margin of the sponge, but there is no great regularity of arrangement. The spicules range from 300 by 8 μ to 600 by 16 μ. (*b*) The middle stratum, (*l. c. m.*) is dense. It is composed of long spicules, compactly grouped; these are tangential, becoming radial at the margin. The stratum is thickest in the center of the sponge, and peripherally is continued into the marginal fringe. The spicules within the limits of the body range from about 1,600 by 17 μ to 4 mm. by 24 μ. The spicules of the fringe (*fr. s.*) range up to 10 mm. by 24 μ. (*c*) The inner stratum is much like the superficial one. The tylostyles, often about 600 by 16 μ, radiate obliquely from the choanosomal margin toward the surface, in general trending toward the fringe border of the sponge.

The occasional slender process borne by the convex face of the sponge includes thickly packed tylostyles arranged lengthwise in the process.

The choanosome contains some, but not many, scattered tylostyles, ranging from 300 by 12 μ to 900 by 16 μ. It is, further, crossed by the ascending radial skeletal bundles (pl. 48, fig. 1. *a. r. b.*). These bundles pass from the central part of the lower cortex to and through the upper cortex. Some, perhaps all, surround oscular canals. The bundles are made up of compactly grouped tylostyles, 1–2 mm. in length and about 20 μ thick, placed lengthwise in the bundle. The bundles expand above, the spicules of the expanded end projecting on the upper surface of the sponge somewhat farther than the surrounding cortical spicules. Thus each osculum is surrounded by a special, although vaguely outlined, fringe of spicules.

Holotype.—Cat. No. 21306, U.S.N.M.

In *T. hemisphericum* Sars from the Arctic Ocean there are several quite long oscular tubes borne on the convex face of the sponge

(Vosmaer, 1885, pl. 1). Doubtless the shape of the individual animal is subject to some change, but it seems improbable that the same (oscular) face could at one time be nearly flat and at another strongly convex. In some other points, however, the Philippine specimen agrees with *T. hemisphericum.* Thus the oscular face in the latter is covered with a furze of short tylostyles, and there are radial ascending skeletal bundles passing from the center of the lower cortex to the upper cortex (Vosmaer, 1885, pl. 2, figs. 17, 18). In Topsent's (1913 *b*, p. 20) specimens (from 72° 37′ north, 20° 0′ east) of this species the general anatomy is as in the *Albatross* specimens. But in the latter the stratification of the peripheral body appears to be much more conspicuous and indeed different in details from that of the Atlantic species.

T. sarsii Ridley and Dendy (1887, p. 218), which the Philippine sponge resembles in general shape, as do some specimens of *T. hemisphericum* (see Vosmaer, 1885, pl. 1), has one comparatively long oscular tube about in the center of the flat face. Round it are a number of "small round, translucent patches," the nature of which is doubtful (Ridley and Dendy, 1887). In the figure given, pl. 43, they look much like the oscular papillae of my form. The cortical skeleton of both surfaces is considerably simpler than in the Philippine species (Ridley and Dendy, 1887, p. 217, fig. 8); the choanosomal spicules form radiating groups; and ascending radial bundles are apparently absent. Thus there are differences, although minute ones. *T. sarsii* occurs in Australian waters, off the Azores, and in the Indian Ocean (Dendy, 1921 *b*, p. 151).

Another species of the genus is *T. irregularis* Ridley and Dendy (1887, p. 220), from off Valparaiso. *Radiella sol* Schmidt (1870, p. 48), from near Cuba is regarded by Hansen (see Ridley and Dendy, 1887, p. 217) and Topsent (1898) as synonymous with *T. hemisphericum.* It has, however, only one oscular protuberance in the center of the upper face, and the fringe spicules project upward (Schmidt, 1870, pl. 4, fig. 6). *Halicnemia patera* Bowerbank (see Ridley and Dendy, 1887, p. 218) is probably yet another species, although Ridley and Dendy think that, in spite of the similarity of external form, this sponge does not belong in *Trichostemma.* The peculiar spicules, however (Bowerbank, 1864, pl. 10, figs. 228–233), on which Ridley and Dendy lay stress seem to be only modified tylostyles, in which case they can scarcely be thought of as a reason for excluding this species from the genus. Topsent (1913*b*, p. 21) has recently described a new and beautiful species, *T. grimaldii*, from the North Atlantic.

Family SUBERITIDAE.

Suberitidinae part O. SCHMIDT, 1870, p. 46.

Suberitidae part VOSMAER, 1887, p. 330.—Part RIDLEY and DENDY, 1887, p. 197.—Plus *Mesapidae* TOPSENT, 1898, pp. 103, 104.

Without a differentiated cortex. Skeleton either not radiate or radiate only in a partial way. Megascleres tylostyles or styles. Microscleres absent or represented in some forms by rhabds (centrotylote microstrongyles, or spinose rhabds that are tylostyles or variants of such).

In addition to *Rhizaxinella* (see below) the genera are *Suberites* Nardo, 1833, *Ficulina* Gray, 1868, *Laxosuberites* Topsent, 1896, *Terpios* Duchassaing and Michelotti, 1864 (see Dendy 1921*b*, p. 148), *Pseudosuberites* Topsent, 1896 (syn. *Suberanthus* Lendenfeld), *Prosuberites* Topsent, 1893, *Axosuberites* Topsent, 1893, *Mesapos* Gray, 1867, and *Tethyspira* Topsent, 1890. For the latter two genera Topsent erected (1898) a special family, Mesapidae, retained in 1900 (p. 252) and 1904 (p. 19). Topsent in 1919 removes *Semisuberites* Carter, 1877 (syn. *Cribrochalina* O. Schmidt in the sense of Vosmaer 1882, 1885; syn. *Plectodendron* Lendenfeld), transferring it to the Desmacidonidae.

Thiele (1898, 1905) discusses the genus *Suberites*. He thinks Topsent's genera *Pseudosuberites*, *Laxosuberites*, and *Prosuberites* should have the value of subgenera. *Terpios* and *Ficulina* should also, he thinks, be classed as subgenera; a new subgenus, *Suberella*, should be made for *Suberites heros* O. Schmidt, and *Suberites* sens. str. be reserved for forms like *S. domuncula* (Olivi).

Dendy, 1905, (p. 130), uses *Suberites* in a comprehensive sense, although he partly indorses Topsent's splitting of the genus into *Pseudosuberites*, etc.

Genus RHIZAXINELLA Keller (1880).

Rhizaxinella KELLER, 1880, p. 272.—TOPSENT, 1898, p. 104.

Pedunculate forms, the peduncle sometimes branched, each branch ending above in a body. Body spherical, ovoid, or cylindrical, with an osculum near the summit; stalk attached to substratum by a plate-like expansion or a set of roots. Megascleres are tylostyles or styles; among them, in several species, sinuously curved forms. Spicules of the body more or less radiately arranged. Peduncle includes, or in the adult state of some species consists of, a dense bundle of longitudinally arranged spicules.

The genus shades over into *Suberites*. (See Thiele's discussion, 1898.) There is an interesting resemblance, especially of certain species, to *Stylocordyla* (see Hentschel, 1909), which differs from *Rhizaxinella* apparently only in the oxeate character of its megascleres. (See Ridley and Dendy, 1887, p. 222).

RHIZAXINELLA NUDA, new species.

Plate 38, fig. 5.

A specimen from station D5512.

The body is club-shaped, about 55 mm. long, 21 mm. thick, rounded above, tapering below, and continued into a hard, bare stem. The latter is irregularly cylindrical, 60 mm. long, 4–6 mm. thick, and ends below in a thin plate-like expansion. A small osculum nearly closed is eccentrically placed on the upper end of the body.

Color very light brown; stem darker. Sponge firm and compact.

Surface of body without eminences, covered with a fine furze of projecting spicules. Stem is continued into body as an axial bundle of spicules, about 3 mm. thick. This ascends two-thirds of the way through the body breaking up at its upper end into indistinctly marked radial tracts, which project upwards and outwards.

The skeleton of the parenchyma of the body consists of large smooth fusiform tylostyles, more or less radially arranged and reaching the surface; not grouped in well-marked bundles; mostly about 2 mm. by 50–60 μ. The degree of tapering from the middle toward the ends of the spicule is considerable; the point is sharp; head small but well marked.

The skeleton of the body includes also a dense ectosomal crust of similar but smaller tylostyles, 600–1,200 by 14–30 μ, which project about 0.5 mm. from the surface. The ectosomal spicules are arranged in conical tufts, the spicules of a tuft diverging. The tufts (bouquets) are however closely set and overlap, so that at and beyond the surface the crust is continuous and not broken up into groups of spicules.

Stem of sponge is stony without a covering of parenchyma and without the ectosomal crust. It is made up of a dense mass of longitudinally arranged and interwoven tylostyles. Some of these are like those of the body parenchyma. Many however are slenderer, nearly cylindrical, and with rounded apex, often becoming tylotes (tylote strongyles). These are slightly curved in an irregularly sinuous fashion; 1,500–3,200 by 28–44 μ. Transitions between the two types occur.

The axial bundle of spicules in the interior of the body includes both the slender sinuous tylostyles or tylotes and the stouter straight fusiform tylostyles. The latter reach a greater length, 3 mm., here than in the parenchyma and are commonly rounded at the apex. The sinuous megascleres are relatively less abundant in this axial bundle of the body than in the stem proper.

Probably in younger stages of this species the parenchyma of the body extends down over the axial skeleton of the stem. But this in the actual specimen is, as said, quite bare, the parenchyma of the body gradually thinning away, from above downwards, to a sharp edge which encircles its upper end.

Holotype.—No. 21294, U.S.N.M.

The remaining families of the suborder, defined and in some measure discussed below, are not represented among the forms studied.

Family CLIONIDAE.

Clionidae TOPSENT, 1887.
Clioniadae GRAY, VOSMAER, 1887.

Hadromerina that bore into and excavate molluscan shells and other calcareous bodies.

The genera are *Cliona* Grant, 1826, *Dotona* Carter, 1880, *Thoosa* Hancock, 1849, *Alectona* Carter, 1879, *Dyscliona* Kirkpatrick, 1900 (see Topsent, 1907, p. xx), *Clionopsis* Thiele, 1905 (see Topsent, 1908), *Poterion* Schlegel, 1858 (see Vosmaer, 1908; George and Wilson, 1919), *Cliothosa* Topsent, 1905 (see Topsent 1920, p. 89), *Heterocliona* Verrill, 1907.

Family STYLOCORDYLIDAE.

Stylocordylidae TOPSENT, 1898.

Pedunculate forms. Skeleton radiate in the body, longitudinal in the stalk. Megascleres diactinal. Microscleres microrhabds or spherasters, or absent.

The genera are *Stylocordyla* W. Thomson, 1873, *Cometella* O. Schmidt, 1870, *Oxycordyla* Topsent, 1904. (For *Halicometes* Topsent see Donatiidae; also see Topsent, 1920*d*, p. 33.)

Family CHONDROSIDAE.

Chondrosidae F. E. SCHULZE, 1877.

With a fibrous cortex. Flagellated chambers small and with special canaliculi (dipodal type). Megascleres have been lost. Microscleres in some forms have been lost.

The genera are *Chondrilla* Schmidt, 1862 (with euasters, which may be of more than one kind), *Chondrosia* Nardo, 1833 (with no spicules). *Thymosia* Topsent, 1895, with horny fibers, is here classed among the *Keratosa* (see *Psammaplysilla kelleri*). Topsent, 1918, p. 603, would add to the family *Chondrillastra*, new genus.

Topsent places the family in his *Carnosa*. In Delage and Hérouard's text and in Minchin's text essentially the same classification is adopted.

Thiele, 1900 (pp. 64–65), pointed out the similarities of the Chondrosidae to *Donatia* (*Tethya* at that time). He regards the family as derived through reduction from *Donatia*-like forms and puts it in the Clavulida (=Hadromerina part). Dendy, 1905 (pp. 107, 130), follows Thiele in ranging the family under the Hadromerina (Astromonaxonellida Dendy) as forms, not primitively simple like the Myxospongida, but in which the megascleres have been lost and in some species the microscleres also.

Hentschel 1909, 1912, likewise places the Chondrosidae along with the Donatiidae. Like Dendy, in the latter's more recent papers, he does not separate the groups Astrophora and Hadromerina (Astromonaxonellida).

Dendy, 1916 (p. 267), would include in the family only *Chondrilla* and *Chondrosia.* He derives the family and the Donatiidae from the Stellettidae, ranging it as one of the astrotetraxonid families which, as said, he does not separate into tetractinellid and monaxonid groups.

Family ASTRAXINELLIDAE.

Astraxinellidae Dendy, 1905.

Dendy, 1905 (p. 107), suggested that certain forms such as *Vibulinus* Gray, 1867, which owing to habitus and the anatomy of the skeleton in general have been referred to the Axinellidae, should be grouped owing to the possession of astrose microscleres in a new family, the Astraxinellidae, of the Hadromerina (Astromonaxonellida). Stephens (1912, p. 59; 1915*b*, p. 28) has followed this suggestion.

In this family fall also *Adreus* Gray, 1867, and *Hemiastrella* Carter, 1879. Topsent, 1919, reviews the latter genus, merging in it not only *Epallax* Sollas, 1888 but *Kalastrella* Kirkpatrick, 1903. Topsent would place it in the Axinellidae alongside of *Adreus* and *Vibulinus.* Hallman (1912, p. 132) adds to the Astraxinellidae his new genus *Paracordyla.* Dendy (1921*b*, p. 107) in his most recent memoir would abandon the family on the ground that the astrose microscleres may be regarded as degenerate acanthostyles. and the genera possessing them may thus be gathered under the Ectyoninae.

(Family Spirasigmidae. A new family has been suggested by Hallman, 1912 (p. 131, footnote), under this name for certain described forms: *Trachygellius* (*Trachya*) *globosa* Carter. *Spirasigma*, new genus for *Gellius aculeatus* Whitelegge. and possibly *Trachycladus* Carter usually classed in the Epipolasidae.)

Suborder SIGMATOPHORA.

Sigmatophora Sollas, 1888.

With tetraxonid megascleres; microscleres when present are sigmas; without desmas.

Family SAMIDAE

Samidae Sollas, 1887.

In addition to the Tetillidae the suborder includes Family Samidae, Sollas, 1887, 1888, represented by *Samus* Gray, 1867, in which the characteristic megascleres are amphitriaenes (Sollas, 1888, p. cxxvi).

Lendenfeld has, 1906, deleted his family Tethyopsillidae. Hernandez, 1914 (p. 21), proposes a new family, Ectyonillidae, for *Ectyonilla*, new genus, *Cantabrina*, new genus, and other (described) genera.

Family TETILLIDAE.

Tetillidae Sollas, 1886, 1888.—Plus *Tethyopsillidae* part, Lendenfeld, 1903.
Tethydae Lendenfeld, 1906.

The characteristic megascleres are protriaenes, which may be very slender, arranged radially. The skeleton in general is usually strongly radiate.

The family includes the following genera: *Tetilla*, *Craniella*, (*Tethya*), *Paratetilla*, *Amphitethya*, *Cinachyra*, *Fangophilina*.

Genus TETILLA O. Schmidt (1868).

Tetilla O. Schmidt, 1868, p. 40 plus *Chrotella* Sollas, 1888, p. cxxv.
Tetilla O. Schmidt plus *Cinachyra* Sollas part plus *Tethyopsilla* Lendenfeld part, Lendenfeld, 1903, pp. 16, 26, 30.
Tethya Lamarck part plus *Cinachyra* Sollas part, Lendenfeld, 1906, pp. 69, 138.

Typically the ectosome is not a distinct layer but shades off into the choanosome; pores and oscula scattered, not located in special depressions. In some species, however, the ectosome is to some extent histologically differentiated and partially assumes the character of a fibrous cortex, thus constituting an approach to *Craniella*. And in some species there are special depressions (probably efferent as well as afferent) on the smooth floor of which are numerous small apertures (subgenus *Cinachyrella*). There is no cortical skeleton of radial megascleres. The microscleres have been lost in some species.

Lendenfeld, 1906, merges *Tetilla* in *Craniella* (*Tethya*) and hence changes the family name to Tethydae. As has been elsewhere said

(George and Wilson, 1919), it seems best to retain both genera. The family name (Tetillidae) remains unchanged.

"*Tetilla*, the simplest and therefore presumably the ancestral genus of the family, has been gradually enlarged in the practice of recent writers by the incorporation in it of atypical species that depart in one direction or another from the central group of typical forms to which Sollas' definition (1888) is applicable" (George and Wilson, 1919). Thus species that have differentiated in the direction of *Craniella*, in that they have the beginnings of a fibrous cortex, are here included (*T. longipilis* Topsent, 1904, p. 97; *T. anomala* Dendy, 1905, p. 91; *T. borodensis* Dendy, 1916*b*, p. 105). Other species are classed here that have differentiated toward *Cinachyra* in that there are superficial poriferous depressions, the floor of which exhibits pore-like apertures, the inhalent or exhalent nature of which is not quite certain (see Kirkpatrick, 1905, Dendy, 1905), but these species lack the fibrous cortex and cortical skeleton of *Cinachyra*. I propose to group them under the subgenus *Cinachyrella*.

Tetilla and its relatives offer excellent illustrations of the fact that sponge genera become more and more difficult to distinguish as the number of known species increases. While this is perfectly well known, a few words on the matter may not be amiss. (See Wilson, 1919, 1919*b*.)

Each genus is of course only a group that has been gradually built up round a type embodying a certain combination of well-marked features or "characters." In the cases of *Tetilla*, *Craniella*, and *Cinachyra*, the main "characters," grouped in pairs (Mendel-wise), the members of which contrast, are as follows:

1. A nonfibrous cortex (*a*) or a fibrous cortex (*A*).
2. Radiating cortical oxeas not present (*b*) or present (*B*).
3. Pores scattered (*c*) or grouped in poriferous depressions (*C*).

Of these characters *Tetilla* typically embodies *a*, *b*, and *c*; *Craniella*, *A*, *B*, and *c*; *Cinachyra*, *A*, *B*, and *C*.

Comparison of many species shows that the characters vary, more properly have varied during the evolution of the present races, independently of one another and hence the number of combinations actually found increases with the number of species known. In the case of the above genera there are more combinations than there are genera recognized, and this is of course often the case in systematics. Thus in the group of species congregated under *Tetilla* we find not only the typical combination but others as well: *A*, *b*, and *c*; *a*, *b*, and *C*.

In such a state of affairs we can either combine genera until we get groups so heterogeneous as to be useless to biology, or we can go on splitting up genera on the plan that each genus shall represent only a particular combination. Thus, on this idea, it would be logical to divide the species now grouped under *Tetilla* into three genera.

But another difficulty faces us here in that the extremes of a character, the sharply contrasting conditions that constitute the members (allelomorphs) of a pair, are so often connected by intergrades. Thus in *Tetilla* between nonfibrous cortex and fibrous cortex there are intergrades. And it may confidently be said that the more intensive grows the study of a group of species, the more of these intergrading series come to be known. Hence it may be expected that the characters above designated as *b* and *B* will, like *a* and *A*, be found to intergrade, and *c* and *C* likewise, if indeed the recorded data do not already justify that conclusion.

In view of the common existence of intergrades between the contrasting members of a pair of generic characters (*a* and *A*, for example), it becomes in the end impossible to split sponges, organisms in general probably, into genera, each of which shall represent a particular combination of characters.

What practice remains then for the classifier who knows that without systematics biological data in general can not be recorded with any certainty that they will be found again, and who therefore must classify, but who does not wish to set up a system of categories which can be precisely defined only because they are artificial and into which, while some organisms go nicely, others can be brought only after a character is pared down in thought, or extended in thought? One way out, and, as I have indicated above, the way into which we have fallen in the case of *Tetilla*, is to recognize larger heterogeneous genera (*Tetilla*, for example) and other smaller, more homogeneous ones. I can not see at present any better way. It is certainly a preferable method—that is, one that enables biologists to find the recorded data more successfully—than that of building up genera, all of which overlap extensively.

Similar considerations apply to subgenera. Where a genus, *Tetilla* for instance, becomes very large and heterogeneous, some grouping of species becomes necessary. And yet because of the intergrading of characters a sharp division of the whole into subgeneric groups is probably only temporarily possible. Forms will, for instance, doubtless be found with pore areas of such a kind as to constitute these forms intermediates between the subgenus proposed below, *Cinachyrella*, and species the whole dermal membrane of which is a sieve membrane (as in *Tetilla ciliata*, for example). I would propose to leave such intermediates in the body of the genus, which thereby still remains heterogeneous.

Subgenera used in this sense are not really groups into which (all) the species of a genus are *divided*, but rather groups which are sufficiently homogeneous to be set off from a still heterogeneous remainder. The advantage in this treatment, if there is one, and it seems to me there is, lies in the result that the assignment of a particular form to a group becomes less dubious than where the attempt is made to divide the whole genus into subgenera, each of which is supposed to be definitely marked by a particular character or combination of characters. If the character or combination is distinctly developed, a subgenus in the sense proposed here is ready to receive the form. If such features are absent, or are not well marked, the form goes in the body of the genus. This remains heterogeneous, and yet it may be greatly reduced in extent by the institution of the several homogeneous subgroups. Such a treatment will, I believe, in the end make it easier both to place and find particular species.

In the body of the genus, as here understood, will fall the species enumerated under *Tetilla* by Lendenfeld, 1903 plus *T.* (*Tethyopsilla*) *stewartii* Lendenfeld, 1888 (p. 45), and the following species not included in, or published later than, his synopsis:

T. (*Chrotella*) *minuta* (Wilson), 1902, page 383.
T. longipilis Topsent, 1904, page 97.
T. (*Chrotella*) *amphiacantha* (Topsent), 1904, page 96.
T. poculifera Dendy, 1905, page 90.
T. (*Tethyopsilla*) *metaclada* Lendenfeld, 1906, page 135.
T. (*Tethya*) *sansibarica* Lendenfeld, 1906, page 89.
T. (*Tethya*) *vestita* Lendenfeld, 1906, page 95.
T. (*Tethya*) *gladius* Lendenfeld, 1906, page 97.
T. (*Tethya*) *hebes* Lendenfeld, 1906, page 98.
T. (*Chrotella*) *ibis* (Row), 1911, p. 311.
T. (*Tethya*) *serica* (Lebwohl), 1914, page 13.
T. dactyloidea, var. *lingua* Dendy, 1916*b*, page 104.
T. pilula Dendy, 1916*b*, page 104.
T. barodensis Dendy, 1916*b*, page 105.
T. furcifer Dendy, 1921*b*, page 9.

Three of the species included in this report fall here: *T. dactyloidea* (Carter), *T. ciliata*, and *T. spinosa.*

For the species falling under *Cinachyrella* see below under that heading.

TETILLA DACTYLOIDEA (Carter).

Tethya dactyloidea Carter, 1869, p. 15.
Tetilla dactyloidea Sollas, 1888, p. 44.

About five dozen specimens taken at "Tacloban Anchorage, about ship; hand dredge."

Since Lendenfeld's Tetraxonia, 1903, where (p. 18) the references are given, the species has been recorded by Dendy, 1916*b* (p. 102, pl. 2, figs. 10 *a–c*), for the coast of Kattiawar (Arabian Sea). A variety living in fresh water has been described by Annandale, 1915.

In the *Albatross* specimens the sponge body is, as usual, elongate and subcylindrical, with a terminal osculum leading from a cloaca, on the wall of which are the apertures of numerous small efferent canals. There is the usual extensive root tuft at the lower end by which the sponge is fastened in the mud.

The *Albatross* specimens very generally are somewhat clavate, enlarged and rounded above, smaller below. A typical specimen is 45 mm. long, exclusive of root tuft; 12 mm. thick above, 6 mm. thick about middle of body, with a cloaca 6 mm. deep. Some small, doubtless young, ones, 12 mm. long by 2.5 mm. thick, were taken. The dense sponge parenchyma contains abundant embryos. The color is light brown, verging on lead gray, but there is reason for believing that the natural color in this species is purple red or yellow (Carter 1887). In my specimens, as in Dendy's (1916*b*), conspicuous bundles of spicules pass obliquely downward and outward from a point just below the floor of the cloaca. At this point the beginnings of the bundles are aggregated, forming a little mass ("skeletal nucleus") that is sometimes conspicuous. These bundles reach the lower end and adjoining region, from which they enter into the root tuft or project freely from the surface.

From the ectosome in general well-marked radial bundles of megascleres are prolonged into the interior. Between these are numerous scattered megascleres. The ectosomal megascleres themselves are arranged in close-set divergent (conical) brushes, each brush including some large oxeas and many very slender protriaenes, most of which project only a short distance, but some far beyond the surface. The ectosomal brushes as seen in surface preparations are sometimes distinct and separate from one another, sometimes continuous with one another.

The spicule measurements, as determined for a few of these specimens, increase, but not greatly, the range of recorded sizes.

1. Oxea, tapering gradually from middle to the sharp points, 1,500–2,000 by 14–16 μ, in the ectosomal and internal bundles. In Lendenfeld's Tetraxonia (1903) 60 μ is given as the thickness of the oxea—obviously a misprint. (See Sollas 1888, p. 44.)

Smaller oxeas of same type, 450–900 by 6–8 μ, scattered everywhere.

2. Ectosomal protriaenes, very slender. Rhabdome 2 μ thick, probably 2–3 mm. long (difficult to isolate whole); clads, making an acute angle with one another, even thinner than rhabdome, hair-like and about 50 μ long.

Stouter protriaenes project here and there from the lower surface. Rhabdome 6–7 μ thick, several mm. long. Clads 3 μ thick at the base, tapering to the point; varying in length but reaching 120 μ; making an acute angle with one another.

3. Anatriaenes. Rhabdome 4–6 μ thick, several mm. long; clads 44–48 μ long; making up the root tufts; abundant also in down-

wardly projecting bundles of the parenchyma, the cladomes situated at or near the surface.

4. Sigmas, fairly stout, 8–10 μ long. Abundant at the surface, present also in the interior. In Dendy's specimens the microscleres were found to be not very abundant.

TETILLA CILIATA, new species.

Plate 39, fig. 2

Station D5431, two specimens. The measurements given below refer to the larger one.

Sponge ovoidal, 35 mm. high, 25 mm. thick. A terminal osculum 4 mm. in diameter leads into a cloaca about 5 mm. deep, into which open a number of efferent canals about 1 mm. wide. There is an oscular fringe 3 mm. high. Sponge is hispid with delicate spicules, projecting about 1 mm. beyond the surface. Over the lower end numerous bundles of spicules protrude which unite to form a root-tuft. This holds together a ball-like mass of débris 12 mm. in diameter.

Color light gray to whitish. Sponge moderately compact and firm. If sponge is expanded (pores and canals wide open), as in one specimen, this surface appears coarsely porous, owing to the subdermal spaces and peripheral canals being seen through the dermal membrane.

Ectosome thin, not fibrous nor distinctly marked off from the choanosome: with small subdermal cavities between the radiating skeletal bundles. Dermal membrane, the usual very thin sheet riddled everywhere with pores.

Skeleton.—Strong radial bundles run from the interior toward the surface, passing in the ectosomal region into divergent brushes. The radial bundles are made up of large oxeas and the rhabdomes of protriaenes. The ectosomal brushes include small oxeas which just reach the dermal membrane, and numerous protriaenes most of which protrude. Oxeas of all sizes are scattered irregularly and thickly throughout the sponge. The oscular fringe includes large oxeas, with smaller sizes, and many protriaenes. The root bundles, in the neighborhood of the sponge body, include large oxeas and small protriaenes, the bulk of the root tuft being made up of very long anatriaenes.

Spicules.—1. Oxea. (*a*) The common type is smooth, equiended, tapering gradually toward each end, 4 mm.—0.5 mm. by 40–7 μ. The largest oxeas occur in the root bundles. In the oscular fringe they reach a length of 3.5 mm. In the body the common large size is about 3 mm. by 30–35 μ. Very many small oxeas occur, ranging from 700 by 12 μ to 450 by 7 μ. (*b*) The oxeas of the ectosomal brushes are, for the most part, distinctly inequiended, about 1 mm. by 8 µ, the thicker end the outer. (*c*) A very few long slender spinulate oxeas, about like those of *T. spinosa*, occur in the oscular fringe and protrude over the general surface.

2. Protriaene. (*a*). The common and conspicuous form protruding over the general surface has a rhabdome 1.5–0.9 mm. by 6–7 µ, clads 80–40 by 3–4 µ; rhabdome as usual tapering from near the cladome to a very fine end; clads straight, often somewhat unequal in length in the same spicule. (*b*). Slenderer forms occurring with the foregoing, having longer and outwardly curving clads. Rhabdome about 2 mm. by 3–6 µ; clads reaching 140 µ in length. (*c*) Hair-like forms occur in abundance along with (*a*) and (*b*); rhabdome about 1 µ thick; clads outcurving, 20–40 µ long. The specific name calls attention to the presence and the location of these spicules which doubtless are young forms, in the sense that they constitute the stock from which class (*b*) is recruited. (*d*). Protriaenes of the root bundles have a long rhabdome of the usual shape, reaching 7 mm. by 14 µ, and long straight clads, 100–180 µ in length. (*e*). Protriaenes of the oscular fringe are chiefly strong spicules with straight clads; rhabdome 6.7–3.5 mm. by 10–20 µ, clads 160–100 by 5–8 µ. Inner part of the fringe includes many smaller protriaenes, in which the clads are only 25–35 µ long.

3. Anatriaene, occurring in the root tuft and in the radial bundles of the lower end of the body. Rhabdome of usual shape, over 8 mm. in length, 8–10 µ thick; clads about 40 µ long.

4. A single plagiotriaene, resembling those figured by Dendy for *T. poculifera* (1905, p. 90), was observed.

5. Sigmas, 10–20 µ long, abundant throughout the interior and at the dermal and gastral (cloacal) surfaces. In the interior the spicules measure 10–16 µ. In the ectosome small sizes are abundant, but larger ones, 16–20 µ, are also common. In the gastral membrane, the spicules measure 10–12 µ.

Holotype.—Cat. No. 21312, U.S.N.M.

The species is close to *T. poculifera* Dendy (1905, p. 90). The most essential difference is the absence of a small oxea (microxea), about 230 µ long, which constitutes a conspicuous element of the skeleton in *T. poculifera.*

There are suggestive resemblances to *T. spinosa* of this report.

TETILLA SPINOSA, new species

Plate 39, fig. 3.

Station D5146, one specimen.

Sponge obconical with the truncated base somewhat convex, 60 mm. high, 35 mm. thick. A single osculum, 2.5 mm. in diameter, at the upper pointed end, leads into a small cloaca about 4 mm. deep, on the floor of which several (five) efferent canals open. Upper and lateral surface smooth, and set off rather sharply from the base which bears small protuberances and is covered with root bundles. The root bundles penetrate and hold a mass of shelly débris and foraminifera, about as large as the sponge body. Color, a light yellowish brown. Sponge firm and compact. Ectosome collenchymatous with small subdermal cavities. Pores scattered over surface between the protruding ectosomal brushes of spicules. Parenchyma with abundant embryos.

The skeleton consists of—

1. Closely set conical ectosomal brushes, about 700 μ deep, protruding only slightly at the surface.
2. Radial bundles of large megascleres.
3. Scattered parenchymal oxeas of many sizes.
4. Long bundles of slender megascleres which descend from the interior of the sponge to the basal surface or beyond it, in the latter case forming the root bundles.

Spicules.—1. Smooth parenchymal oxea, of many sizes up to 3.8 mm. by 40 μ; the two ends not noticeably dissimilar; scattered everywhere, the larger nearer the center of the sponge.

2. Large, smooth oxea, 1.5–2 mm. by 28–40 μ; inequiended, the thicker end being the outer; in radial bundles.

3. Ectosomal oxea, 400–650 by 2–6 μ; smooth; inequiended, thicker end the outer; in the ectosomal brushes.

4. Spinose oxea, 3 mm. by 6–8 μ; inequiended, thicker end the outer. The spines project inwards, are fairly strong in the larger spicules, feeble in some of the slenderer. In the radial bundles and moderately abundant, although distributed without any apparent regularity.

5. Slender ectosomal protriaenes. Rhabdome 500 by 2 μ; clads still slenderer, 12–16 μ long. The most abundant spicule in the ectosomal brushes.

6. Larger protriaenes. Rhabdome 3 mm. by 7–10 μ; clads 30–100 μ long. In radial bundles.

7. Anatriaenes, forming the root bundles and the bundles which descend from the interior to the basal surface of the sponge. Rhabdome very long, certainly 1 cm.; 12 μ thick near cladome, tapering quickly to 4 μ, thickening again gradually to 8 μ, and finally tapering gradually toward the point. Clads 60–76 μ long.

8. Sigmas. Commonly 8–12 μ long, but reaching 16 or even 20 μ in length. Abundant at the surface and in interior.

The species is especially characterized by the spinose oxeas, in less degree by the slenderness of the small protriaenes.

Holotype.—Cat. No. 21303, U.S.N.M.

(TETILLA) CINACHYRELLA, new subgenus.

Cynachyra part LENDENFELD, 1903, p. 26.

Species of *Tetilla* in which there are poriferous pits (smooth and sphinctrate depressions, the wall of which is a sieve-membrane) but which lack the cortex characteristic of *Cinachyra*.

Tetilla hirsuta Dendy (1889, p. 75; 1905, p. 89) and perhaps some of the other species enumerated under *Cinachyra* by Lendenfeld, 1903, fall here. It may be noted that *Tetilla* (*Cinachyra*) *malaccensis* Igerna B. J. Sollas, 1902 (p. 219), from the Malay Peninsula, was not included in Lendenfeld's list. The following species published since Lendenfeld, 1903, also fall here:

Tetilla limicola Dendy, 1905, p. 93.
Tetilla (*Cinachyra*) *anomala* Dendy, 1905, p. 91; 1921*b*, p. 20.
Tetilla (*Cinachyra*) *isis* Lendenfeld, 1906, p. 143; Dendy, 1921*b*, p. 16.
Tetilla (*Cinachyra*) *hamata* Lendenfeld, 1906, p. 145.
Tetilla (*Cinachyra*) *alba-tridens* Lendenfeld, 1906, p. 149.
Tetilla (*Cinachyra*) *alba-bidens* Lendenfeld, 1906, p. 151.
Tetilla (*Cinachyra*) *alba-obtusa* Lendenfeld, 1906, p. 154.
Tetilla (*Cinachyra*) *vertex* Lendenfeld, 1907, p. 310.
Tetilla (*Cinachyra*) *vertex*, var. *monticularis* Kirkpatrick, 1908, p. 11.
Tetilla cinachyroides Hentschel, 1911, p. 281.
Tetilla (*Cinachyra*) *phacoides* Hentschel, 1911, p. 285.
Tetilla (*Tethya*) *clavigera* Hentschel, 1912, p. 327.
Tetilla (*Cinachyra*) *mertoni* Hentschel, 1912, p. 332.
Tetilla (*Cinachyra*) *nuda* Hentschel, 1912, p. 333.
Tetilla (*Cinachyra*) *vaccinata* Dendy, 1921*b*, p. 14.
Tetilla (*Cinachyra*) *providentiae* Dendy, 1921*b*, p. 18.

The species included in this report which fall under *Cinachyrella* are, in addition to *Tetilla hirsuta* Dendy and *T. clavigera* (Hentschel), *T. crustata*, together with var. *patellae-spinosae* and the forms *aperta* and *hispida*, *T. paterifera*.

TETILLA (CINACHYRELLA) HIRSUTA Dendy.

Tetilla hirsuta DENDY, 1889, p. 75; 1905, p. 89; 1916*b*, p. 104.
Cinachyra hirsuta (Dendy) LENDENFELD, 1903, p. 28.

Malchochin Harbor, Linapacan Island, one specimen. There are some differences in spicule measurements (see below), but the *Albatross* sponge fits well in Dendy's species, agreeing with the type (Dendy, 1889, p. 75) not only in possessing poriferous pits, but also in regard to the structure of the ectosome, the general shape, color, and size of the body, the hirsute nature of the surface, and the presence of a central "nucleus" from which the skeletal bundles radiate.

The specimen is roughly hemispherical and was probably attached by the under surface, which is smooth and shows distinctly the radiating skeletal bundles. Horizontal diameter about 30 mm. The projecting spicules of the upper and lateral surfaces have caught a quantity of dirt.

Small massive buds are present in considerable number at the surface, impaled on the long spicules. Doubtless in correlation with this condition the surface is made uneven by numerous small eminences.

The poriferous pits are all small, a typical one measuring 1.6 mm. in diameter, 1.1 mm. in depth. They are abundantly scattered over the upper and lateral surfaces, but owing to the dirt and projecting spicules are inconspicuous. Some of the pits are narrow and cleftlike, a shape which I take to be due to contraction. The membrane lining the pits is smooth, and perforated with closely set pores. Dendy regards some of the pits as afferent, others as efferent, and this seems probable. Still I find a few simple apertures, 1–2 mm. in diameter, scattered over the upper surface that seem to be oscula.

The radiating skeletal bundles are made up of large oxeas together with protriaenes and anatriaenes. The spicules projecting at the surface are oxeas with intermingled protriaenes.

The oxeas range down from 4 mm. by 50 μ, thus agreeing well with the type.

The protriaenes of the general surface have a rhabdome 4–6 mm. long, 14 μ thick near the cladome, then tapering to a hair-like thickness; clads 70–150 by 5–7 μ thick at the base. The spicules are only fairly abundant, some projecting while the cladomes of others lie in the ectosome. The protriaenes of the type are smaller, but it may be that *entire* spicules were not measured. One suspects, perhaps without warrant, that this was the case both for protriaenes and anatriaenes, the rhabdomes of which are given as 460 μ or less in length.

Dendy does not describe the protriaenes of the poriferous pits, to which I therefore give a few words. A pit is bounded all around by radial skeletal bundles which include many protriaenes. These lie chiefly on the side next the pit. Some pass out radially with the oxeas, but many bend away from the bundle inclining themselves in an obliquely radial direction toward the pit, the wall of which thus becomes covered with the projecting cladomes of these spicules. Such protriaenes are much smaller than those of the general surface, the rhabdome varying down to a thickness of only 4 μ, the clads to a length of 30 μ.

The anatriaenes lie in the radial bundles, the cladomes in the ectosome at different levels but not far apart. The more internal spicules are evidently the younger, having shorter rays and more expanded cladomes. The anatriaenes are fairly abundant. The rhabdome is several millimeters long, in a particular case 2.8 mm.; about 5 μ thick near the cladome, then becoming hair-like; clads 55–80 μ long.

The sigmas in the type have a length of 22 μ. They are smaller, only 10–12 μ long, in the *Albatross* specimen. They are abundant in the dermal membrane and in the interior, especially in the canal walls.

Spheres were found in only one of Dendy's specimens (Dendy, 1905, p. 90). They are present in the *Albatross* specimen; scantily scattered in the choanosome; more common in the ectosome, but here only abundant in the walls of some of the narrow canals. They are spheroidal or slightly irregular, 2–8 μ in diameter; sometimes packed closely together in little groups of 2–4, occasionally looking as if they were fusing.

Owing to the smaller size of some of the spicules, especially the sigmas and until the measurements are better known for more specimens from different localities, the *Albatross* sponge might be provisionally held apart from the type as a variety.

T. hirsuta has been recorded from the Gulf of Manaar (Ceylon) and the west coast of British India (Okhamandal in Kattiawar). Two closely related forms are *T.* (*Cinachyra*) *voeltzkowi* Lendenfeld, from Zanzibar (Lendenfeld, 1897), and *T. cinachyroides* Hentschel, from southwest Australia (Hentschel, 1911, p. 281). The latter has a small variety of oxea which marks it off. The former seems to differ from Dendy's species only in spicule measurements, and should probably be merged into it.

TETILLA (CINACHYRELLA) CLAVIGERA (Hentschel)

Plate 39, fig. 4

Tethya clavigera HENTSCHEL, 1912, p. 327.

Station D5169, one specimen.

Hentschel had two fragments from the Aru Islands. These he interpreted as belonging to a massive, spheroidal or hemispheroidal sponge. This inference is confirmed by the *Albatross* specimen which is subspheroidal, 70–80 mm. in diameter, with no base or obvious surface of attachment.

The vestibular spaces or poriferous pits are scattered abundantly and yet not thickly over the whole surface. They have the same shape as in the type specimen, each being a radially elongated ellipsoidal sac opening to the exterior by a narrower canal. They are larger than in Hentschel's specimen, a typical pit measuring 11 mm. in depth, with a bottom width of 5 mm. and a circular aperture 2 mm. in diameter. Some of the apertures are surrounded by short, rather vague, fringes of projecting spicules. Probably where the fringes do not occur, they have been rubbed off. In each pit that was opened, a small commensal ophiuroid was found. The wall of the pit is smooth. It doubtless is studded with pores in the expanded state of the sponge, but in the actual specimen is aporous. Nevertheless in spots what seemed to be traces of closed pores were visible. As in the type specimen, small protriaenes were seen in places to project obliquely over the wall of the pit.

As in the type no oscula, apart from the poriferous pits, were to be seen. The pits are probably therefore in part efferent, in part afferent.

The specimen agrees with Hentschel's in being incrusted with shelly débris, etc.; in the dense character of the ectosome, which, however, does not include a fibrous stratum; in the arrangement of the megascleres, ectosomal brushes of smaller spicules being absent. The distinctness of the radial skeletal bundles is lessened somewhat by the presence of radial megascleres scattered between them. The sponge is heavy and very compact, all the canals being small. The ectosome measured about 500 μ in thickness and no subdermal cavities could be seen.

The *Albatross* specimen is much larger than that from which Hentschel's pieces came, and may be looked on as an older specimen. It comes from a different locality. One would expect to find, then, spicule measurements different from Hentschel's, and in fact the spicules are considerably larger.

Oxeas, in general equiended, tapering, 2.5 mm. by 16 μ to 6 mm. by 50 μ; the chief radial spicule and chief spicule in fringe of poriferous pit. Small equiended oxeas, commonly 180–200 by 3–4 μ, are scattered in some abundance through the parenchyma. They perhaps represent young stages.

Protriaenes are almost absent over the general surface of the sponge. The very few seen had short, stout clads 36–40 μ long, rhabdome long and 16–30 μ thick near cladome. Protriaenes are common in the fringes of the pits. Here they have a long, tapering rhabdome, reaching several millimeters in length, about 16 μ thick near cladome; clads 50–70 by 12 μ. Smaller, slenderer protriaenes project obliquely from the lateral walls of the pits, in places. The protriaenes in the type specimen are very slender.

Anatriaenes are common, along with the radial oxeas. The cladomes of many lie in the ectosome, but there are also many that project beyond the surface of the sponge about 1–2 mm. The rhabdome is 12 μ thick near the cladome, then tapering to a hair-like thickness, about 7 mm. long, often somewhat sinuous where wrapped round the large oxeas. Clads in a typical spicule measure 56 by 12 μ. The anatriaenes in the type specimen are very slender.

Anatriaenes with completely degenerate clads, the spicule ending distally in a knob, occur less frequently than in Hentschel's specimen. Intermediates between these and the regular anatriaene also occur. In some of them only one or two clads are completely degenerate. In others one or two clads are simply shorter than the normal. In the related *Tethya coactifera* Lendenfeld (1906, p. 75) the triaenes exhibit similar variations to those of this species.

The sigmas are abundant, simple contort, 14–16 µ long (7–11 µ in the type specimen).

TETILLA (CINACHYRELLA) CRUSTATA, new species.

Plate 39, fig. 5; plate 48, fig. 5.

Station D5152, 10 specimens; station D5134, 1 specimen; station D5179, 1 specimen; station D5478, 4 specimens; station D5337, 1 specimen.

Body massive, somewhat flattened, often greatly flattened, from above downward, with rounded or polygonal equatorial outline; sometimes nearly spheroidal; pyriform in youth, with the small end up. Vertical thickness of body ranges from slightly less than to one-half the greatest horizontal diameter, which in these specimens measures 40 to 75 mm. Under surface generally torn and then showing the radiating skeletal bundles. Perfect specimens show that even in the subspheroidal individuals this surface is generally flattended; nevertheless in one such specimen it is more convex than the upper surface. It bears root spicules which in one of the adults (70 mm. in horizontal diameter), doubtless representing the normal condition, are abundant over the marginal region of this surface. These spicules together with the entangled sand are matted together into a mass 10 to 20 mm. thick. In the other specimens the root spicules are inconspicuous, doubtless having been broken off.

The surface in general often appears smooth, or nearly so, to the eye, but in other places or specimens is covered with a thin incrustation of sand. Examination shows that the megascleres of the radial bundles normally project a short distance, about a millimeter or less. The radial bundles are so abundant in many places that their projecting spicules form a practically continuous covering, which of course catches sand. In other places there are pretty large intervals between the radial bundles, and, although in the intervals there are some medium-sized and small projecting oxeas, over such parts of the surface whatever fur there is, is scanty even in the natural unrubbed state. Smoothness of the surface in general is of course largely due to the fact that the projecting spicules have been rubbed off. Several of the specimens are infested with small brown actinians, which project from the surface.

On the upper surface, and especially round the upper part of the lateral surface, or round the margin of the very flattened specimens, are the apertures of poriferous pits. The apertures are 2–5 mm. in diameter, each surrounded by a fringe of projecting spicules, which is sometimes thick and close and 3 mm. in length; fringe often more or less worn down. The pits have no constant arrangement, although there is sometimes a central one; this is apical in a pyriform young specimen 40 mm. in diameter. They usually number 8–12 on a sponge. The pits are smooth walled and of the same elongated ellipsoidal shape as in *T. clavigera.* The radial depth is 10–20 mm., bottom width 7–9 mm. The wall in some is uniformly perforated with thickly set minute pores leading into canals that abut against the wall. But in the case of other pits apertures easily visible to the eye, 1 mm. or thereabout in diameter, occur scattered over the general poriferous surface. And in some cases the whole or a large part of the pit wall is covered with apertures visible to the eye, ranging down from 0.5 mm. in diameter to small pores. No other apertures than those of the pits are found on the surface of the sponge, and it would seem therefore that some of the pits must be afferent, others efferent.

The pits contain a great deal of shelly débris, and usually commensal ophiuroids. Projecting obliquely from the wall are small (trichodal) protriaenes; rhabdome about 2 μ thick, clads 12–20 μ long.

The ectosome does not include a distinct fibrous stratum, although in its deeper part are numerous fiber cells disposed tangentially in isolated tracts. Its outer part is occupied by a dense crust, 350–600 μ thick, of tangentially disposed oxeas (pl. 48, fig. 5, *a–b*). In the young specimen referred to above this crust is only 150–250 μ thick. Brownish granular cells are scattered in the dermal layer and through the choanosome. The sponge is firm; often rather porous owing to the number of small canals, 1–2 mm. in diameter. Some specimens are more compact. Color brown, often dark.

Strong skeletal bundles extend radially from the center of the sponge to the surface, there expanding in the usual way. There are no radial ectosomal brushes of smaller megascleres. The radial bundles include abundant oxeas, protriaene forms, and some anatriaenes. Fringes of the poriferous pits include oxeas, protriaenes, and prodiaenes. The root spicules include protriaenes and very many anatriaenes.

Spicules (pl. 48, fig. 5).—1. Oxeas. Large equiended spicules, 7–9 mm. by 60–90 μ, along with smaller ones, are abundant in the radial bundles, sometimes projecting. In the specimen from station 5134 the radial oxeas of the under surface reach a length of 11 mm. Similar oxeas, ranging from 1 mm. by 20 μ to less than half that size, are scattered abundantly through the choanosome. The tangential ectosomal oxeas are like those of the choanosome.

2. Protriaenes. (*a*) Protriaenes, prodiaenes, and promonaenes occur abundantly in the radial bundles, the promonaenes and prodiaenes being especially conspicuous and characteristic. The rhabdome in these spicules is about 4 mm. by 16–24 μ; clads with a basal thickness about equal to that of rhabdome. The single clad of the monaene, whch in some specimens (station 5478) may be irregularly curved in and out, is 200–350 μ long; on the under surface (station 5134) it may reach 500 μ in length; very rarely it is dichotomous (station 5478). In the diaenes the clads are 120–250 μ long; very rarely the clads may spread out almost at right angles to the rhabdome. In the protriaenes the clads are in general shorter and slenderer than in the prodiaenes, but the range in size is about the same. Any or all of these protriaenes forms may project a short distance beyond the surface of the sponge.

(*b*) Protriaenes of a stouter type project from the radial bundles in some abundance over the general surface and occur among the root spicules; rhabdome long and 20–35 μ thick; clads shorter and relatively stouter than in type *a*, 50–100 μ long; one clad sometimes aborted.

(*c*) Protriaenes of the fringes round the apertures of the poriferous pits have a long rhabdome, 9–10 mm. long, 16–24 μ thick, with clads 100–175 μ long. Smaller ones also occur. From the adjacent part of the lateral wall of the pit quantities of very small trichodal protriaenes project obliquely upward.

3. Anatriaenes. (*a*) In the anatriaenes of the radial bundles in general the rhabdome is 5–10 mm. long, 8–12 μ thick, then becoming hair-like; clads 20–50 μ long. These spicules are not abundant in the preparations made from some specimens (station 5152) but are more abundant in those made from others (stations 5134 and 5179). Many project beyond the surface.

(*b*) Anatriaenes of the under surface reach a larger size than those of the upper and lateral surfaces and are also more abundant, many projecting. They form the chief element in the root bundles. The rhabdome measures about 10 mm. by 20 μ, clads 40–90 μ long.

4. Sigmas. In the ectosome and adjoining zone of the choanosome, the sigmas, which are very abundant, measure commonly 28–36 μ in length, the spiral being long and open and generally showing two convexities; smaller ones are intermingled. The spicule is frequently so bent in the middle (see *Chrotella macellata* Sollas) as to have something of the appearance of a toxa. In the choanosome in general the sigmas are shorter, about 16 μ long, and of the typical simple contort shape.

Holotype.—Cat. No. 21316, U.S.N.M.

The considerable number of the specimens included in the collection makes it possible to eliminate from the species-idea minor features due to accident or such as are strictly local. The characteristic features are, then, the ectosomal crust of tangentially disposed oxeas, the large promonaenes and somewhat smaller prodiaenes of the radial bundles, the projecting protriaenes (including diaenes) with short, strong clads, the difference in size and shape of the ectosomal and choanosomal sigmas. Including the *forms* described below there is very considerable diversity within the species not only in the matter of shape, but as respects the hirsuteness of the surface and the termination of the efferent canals. But the skeletal peculiarities are essentially the same throughout the series of specimens, and it seems necessary to group all of the latter together as one species.

The specimens from the different localities vary as to size of the megascleres. For instance in the specimen from 5179 all of the megascleres average a larger size than in those from 5152.

The species is related to *T. (Cinachyra) isis* Lendenfeld (Lendenfeld 1906, p. 143) from the northwest coast of Australia. It is also certainly very close to *T. (Chrotella) macellata* (Sollas) from the Philippines. No mention is made, however, in the case of the latter species of the ectosomal crust of oxeas. The "cloacae" opening by "oscula" in Sollas' species seem to correspond to the poriferous pits of *T. crustata.*

TETILLA (CINACHYRELLA) CRUSTATA forma HISPIDA, new form.

At station D5442 was taken the largest of all the specimens of this species. The sponge has a horizontal diameter of 115 mm. with a vertical diameter of 75 mm., and is subspheroidal with a large flattened base, approaching the hemispheroidal shape.

Over the latero-superior surface are a few smooth areas, evidently worn smooth, but the surface in general is covered with a continuous fur of spicules projecting 2–3 mm., formed by protruding elements of the radial bundles. This conspicuous fur makes the peculiarity of the *form.* It is useless to speculate as to its genetic value. Perhaps any individual of the species growing up under similar conditions would acquire it.

The flattened basal surface, smooth in the center (worn perhaps), is elsewhere thickly covered with spicules projecting outward and downward 5–8 mm.

The poriferous pits are numerous and of the usual type, some 20 mm. deep. Most are on the latero-superior surface, a few on extreme upper surface. Many are closed, and in such cases the spicules of the marginal fringe have come together, forming a papilla, 3–4 mm. high, which conceals the aperture. No other apertures or specialized areas (see var. *patellae-spinosae*) are present. The sponge is infested with the small brown actinian, so commonly present in this species. The ectosomal anatomy and skeletal arrangement are as in the type.

Spicules.—1. The oxeas are as in the type.

2. (*a*). The large promonaenes of the radial bundles are perhaps a trifle smaller than in the type. The clads measured were 180–300 μ long, sometimes irregularly wrinkled or bent, sometimes curved into a hook-shape, sometimes with two bold curves like the horns of certain cattle.

The prodiaenes of the radial bundles are likewise somewhat smaller than in the type. The clads measured were 90–180 μ long, sometimes unequal in length; often irregularly wrinkled or bent, sometimes symmetrically so—that is, both clads bent alike.

(*b*). The projecting protriaenes of the radial bundles are like those of the type, perhaps in the average slenderer, the rhabdome 6–8 mm. long and about 24 μ thick, the clads 50–100 μ long. These are the chief elements of the surface fur.

(*c*). The protriaenes of the fringes of the poriferous pits are essentially as in the type. The rhabdome may be as thick as 28 μ, the clads as long as 250 μ.

The anatriaenes and sigmas are as in the type.

Four other specimens smaller than the above were taken at the same station. They range in shape from subspheroidal to hemispheroidal or are even more flattened. They all have the flattened basal surface so common in this species. They are all hirsute in places, but have evidently been more or less rubbed.

Holotype.—Cat. No. 21308, U.S.N.M.

TETILLA (CINACHYRELLA) CRUSTATA forma APERTA, new form.

Station D5593, one specimen.

The essential point of difference from the type lies in the presence of unmistakable oscular canals which are easily distinguishable from the poriferous pits. Whether this is a structural and fixed point of difference between races, or whether it is a feature of physiological anatomy (as, I think, it may turn out to be), one, that is, which varies with the physiological state of the individual, it is not possible to say. It is quite conceivable that in one and the same poriferous pit the lining membrane may at certain times be perforated uniformly with many minute apertures, at other times with fewer but larger ones, and that at still other times the apertures may coalesce until all trace of a perforated lining membrane disappears, the efferent canals then opening directly into the pit. This would now be called a cloaca, or if one of the efferent canals happened to be much larger than the others, it would appear simply as the prolongation of such a canal.

The form comes from a different locality from those where the type was taken, and with the difference in canal anatomy are associated other differences. But these, especially the spicule measurements, are only such as generally characterize colonies of individuals belonging to the same species but living at some distance from one another. They constitute the now well recognized "geographical mark".

Sponge is irregularly spheroidal, 75 mm. in diameter. Upper and latero-superior surfaces bear numerous, 11, apertures, 2–5 mm. in diameter. Several of the larger are oscula. The others, 2–3 mm. wide, are the openings of the poriferous pits. Both are surrounded by spicular fringes, although these in many cases have been nearly rubbed off. The general surface is undoubtedly covered in nature with a scanty furze of spicules projecting about 1 mm., but these have been rubbed off over a large part of the surface, leaving the dermal membrane smooth. The lower surface is covered with projecting bundles of root spicules, which combine to form a tangled mass that covers the base of the sponge to a thickness of a few millimeters but does not form an elongated root tuft. Sponge, dark brown, both internally and at the surface.

Some of the oscula are the apertures of large efferent canals, which may be as wide as 8 mm., and which penetrate far into the sponge. The lining membrane of the canal for some millimeters internal to the osculum appears porous, although most of the pores are closed. In other cases the osculum leads into a comparatively shallow cavity, on the floor of which open several, 4–5, efferent canals, 1.5–2 mm. in diameter.

The poriferous pits are smaller than in the specimens of the type, a typical one measuring 8 mm. deep, 4 mm. wide, with an aperture 2–3 mm. wide. The lining membrane is abundantly perforated by small apertures, although these are not numerous enough to make the membrane sieve-like. Most apertures are 20–30 μ in diameter, but they intergrade with numerous larger ones about 85 μ in diameter. The dermal membrane at the surface of the sponge shows no pores.

The skeletal arrangement immediately surrounding the oscular canals and the poriferous pits is the same. It consists of numerous radial skeletal bundles which support the lateral wall of canal or pit and project at the surface, forming a marginal fringe round the aperture. This consists chiefly of protriaenes. Internal to the aperture are the usual very delicate protriaenes projecting obliquely from the lateral wall.

The large oxeas of the radial bundles are smaller than in the type specimens. Moreover, they exhibit two well-marked patterns (*modes* round which very many of the spicules may be grouped), a slenderer and a stouter, which, however, intergrade. The one type measures about 5 mm. by 50 μ, the other 3 mm. by 100 μ.

The common large promonaenes, prodiaenes, and the protriaenes of the radial bundles do not differ from those of the type.

The stout form of protriaene with cladome projecting beyond the surface is present as in the type. A few were observed in which one and even two clads were completely degenerate.

The protriaenes of the marginal fringes possibly average a larger size than in the type, clads of the larger ones observed ranging from 180 to 280 μ in length.

In this form, as said, root bundles are abundant. Long, stout protriaenes with short clads are common in them. The rhabdome is over 11 mm. long, about 36 μ thick above, clads 50–70 μ long, 20 μ thick at the base.

The anatriaenes of the radial bundles are like those of the type. They are common in this specimen. The anatriaenes of the root bundles are like those present on the under surface of the type.

The sigmas of the ectosome and interior show the same contrast as in the type. The former are 28–44 μ long, the latter 16–20 μ long.

Holotype.—Cat. No. 21318, U.S.N.M.

TETILLA (CINCHYRELLA) CRUSTATA, var. PATELLAE-SPINOSAE, new variety.

Plate 39, fig. 7.

Station D5335, 23 specimens.

The shape is remarkably uniform. The sponges are subspheroidal with a noticeably flattened basal surface; diameter in most of them 70–85 mm., but ranging down to 40 mm. The general surface is smooth or nearly so, but examination shows that, as in the type, the spicules of the radial bundles naturally project. Over the lowermost part of the lateral surface just above the base, projecting spicules are present in abundance in some of the specimens (doubtless rubbed off in others); they protrude downward and outward a few millimeters. Over the basal surface, in all but one specimen, the projecting (root) spicules have been for the most part rubbed off. But in this one specimen the whole basal surface is covered with a mat of root spicules, which holds a quantity of sand; the mat is now only a few millimeters thick, doubtless compressed artificially. Density and color as in the type.

The poriferous pits are numerous and resemble those of the type; depth in two representative pits, 13 mm. and 20 mm. As in specimens of the type which are high enough to have a considerable area of lateral surface, the pits occur especially on the laterosuperior surface, much more rarely on the extreme upper part of the body. The lining membrane of the pit is smooth and finely porous, in upper part of pit showing the usual trichodal protriaenes. Apertures of pits in general round, sometimes becoming slit-like in closing; those widest open measure 6 mm. in diameter. Fringes as in type, but very often worn down.

What distinguishes these specimens at a glance from the type is the presence of more or less circular, depressed, shallow, spinous areas (doubtless oscular) on the upper surface of the body. Of these there are often three or four in a specimen, but I have counted as many as five and as few as two or, in the smallest specimen, only one. The diameter of the areas ranges in general from 10 to 20 mm., the depth from 1 to 3 mm. Both the margin and general surface of the area are typically thickly covered with spicules that project about 2 mm; these have been more or less rubbed off in many areas. The covering spicules of the area catch and hold sand in some quantity. The surface of an area shows either no apertures at all or a number of quite small ones, a fraction of a millimeter in diameter. These are doubtless oscula; where they appear to be absent, they no doubt are simply closed. No other oscula occur in the sponge. The small oscula of this variety evidently correspond to those described by Kirkpatrick (1905) for *Cinachyra barbata*, although their distribution is different. If the inferences generally drawn from anatomy are correct, it would seem that in this species we have two classes of oscula, the small ones of this variety and the large ones of forma *aperta*. One may hazard the guess that there are both afferent and efferent poriferous pits, the detailed features of which vary with the physiological state, and small oscula as well.

The ectosomal anatomy is as in the type. The skeletal arrangement is as in the type. As in the type, the specimens are commonly infested with a small brown actinian.

Spicules.—1. The oxeas of radial bundles, ectosome, and choanosome are as in the type.

2. (*a*). The promonaenes of the radial bundles are as in the type; rhabdome commonly about 28 µ thick; clad commonly 200–250 µ long. The prodiaenes and protriaenes of the radial bundles do not differ from those of the type.

(*b*). Protriaenes and prodiaenes with short and comparatively stout clads, 35–85 µ long, project from the radial bundles over the general and basal surface as in the type.

(*c*). Protriaenes of the fringes of the poriferous pits, thickly crowded and resembling those of the type; rhabdome 8–10 mm. long, clads 70–150 µ long. The prodiaene is commoner than the triaene form.

(*d*). Protriaenes and prodiaenes of the fringes and general surface of the oscular areas, thickly crowded and like those guarding the poriferous pits.

3. Anatriaenes of radial bundles like those of type; some projecting from general surface. Anatriaenes of under surface like those of type.

4. Sigmas of ectosome and interior show the same contrast in size and shape as in the type. Those of the ectosome measure 20–32 μ in length, those of the interior 16–20 μ.

Holotype.—Cat. No. 21310, U.S.N.M.

TETILLA (CINACHYRELLA) PATERIFERA, new species.

Plate 39, figs. 6, 8; plate 48, fig. 4.

Station D5169, three specimens.

Sponge massive, somewhat elongated vertically, larger and rounded above, narrower below where the body is probably naturally buried in the sand. The largest specimen is 95 mm. high with a greatest diameter of 60 mm., the others not far from these dimensions. A single osculum, terminal in two, lateral in one specimen, leads from a cloaca. In one specimen the osculum is 4 mm. wide, the cloaca 6 mm. deep, 5 mm. wide. In a second specimen the dimensions are about the same. But in one specimen the osculum (terminal) is 12 mm. wide, the cloaca 25 mm. deep, with a width of 12 mm. The oscula are without fringes. The surface of the cloaca shows the apertures of a few small efferent canals.

The poriferous pits are very numerous, distributed over the whole surface except the base, or only over the upper and lateral surfaces. They are shallow, obviously sphinctrate, having a sharp margin when they are contracted (pl. 39, fig. 6), a vague and rounded margin when not contracted (pl. 39, fig. 8). The largest measures 8–10 mm. in diameter, with a depth of 2–3 mm. They range down to small ones about 1 mm. wide. In two of the specimens the pits do not exceed 4–5 mm. in diameter. There is no fringe. The floor is smooth and so perforated with pores as to be sieve-like. As bearing on the ontogenetic and evolutionary origin of the pits, it is interesting to note that over the lower lateral surface there are pits that are scarcely depressed and other similar smooth pore areas that are not depressed at all. Microscopic preparations show that between the poriferous pits there are also some scattered pores.

The surface in general between the poriferous pits is glabrous, very feebly and minutely conulose. But over the lower lateral surface are areas that are hirsute or produced into long downwardly projecting slender root processes which include bundles of root spicules. Such areas are more or less covered with shelly débris.

The narrowed basal part of the sponge may be simple, the whole sponge pear-like; or the base may be somewhat irregular showing a tendency to become lobate. There is no root-tuft, but the base is covered with projecting root-processes which hold shelly débris.

The color is light brown in two specimens, darker in the third. The choanosome is dense. The ectosome is likewise dense, somewhat fibrous in its superficial stratum and without radiate cortical oxeas.

Strong skeletal bundles curve out radially from the center of the sponge to the surface. In the peripheral region, the bundles are not very sharply separated one from the other. Over the general surface the superficial spicules project slightly in groups that are quite small, with much dermal membrane between them that shows no megascleres. The radial skeletal bundles are present and alike, both within the limits of the poriferous pits and between the pits. There are no special ectosomal brushes of smaller spicules in which the radial bundles terminate. The extreme basal part of the sponge contains abundant, in fact consists chiefly of, strong, vertically descending spicule bundles that fray out at the lower end.

Over the surface in general the radial bundles are made up chiefly of oxeas with intermingled protriaenes. Root bundles of the base and lower lateral surface include also many anatriaenes.

Spicules.—1. Oxea. Smooth, equiended, tapering gradually to sharp points. In the radial bundles they measure 2.5–4 mm. by 35–50 μ, with smaller, slenderer ones. In the root bundles they reach a larger size, 4.5 mm. by 65 μ.

Small oxeas, about 250 by 2 μ, scattered through the choanosome, are fairly abundant in two specimens, and almost absent in the third. Probably a detailed examination would show that the different regions of one and the same individual differ a good deal in respect to this point.

2. Protriaene. Common but not very abundant in the radial bundles and the root bundles, less common in one than in the other two specimens. Spicules in the radial bundles have a rhabdome 3–4 mm. long, 8–12 μ thick above; clads 24–60 μ long, 5–7 μ thick at the base. In two specimens, spicules with shorter, stouter clads (34–40 μ long, 6–7 μ thick) predominate. In the third specimen, spicules with slenderer clads (40–60 μ long, 5–6 μ thick) predominate. In this specimen prodiaene and promonaene forms were noted.

In the root bundles stouter protriaenes occur along with the ordinary forms; rhabdome 16–22 μ thick, clads 24–28 μ long and quite thick. Some protriaenes also occur here, of ordinary size, but with clads so degenerate as to form mere protuberances.

3. Anatriaene. Absent in the radial bundles of the general body, common in the root bundles of the lower body and base. Spicules characterized by a very flat cladome. In a typical spicule (pl. 48, fig. 4, *a*) rhabdome is several millimeters long, 12 μ thick above; clads short, stout, almost at right angles to the rhabdome, about 24 μ long, 12 μ thick at the base. Slenderer but similar spicules also occur, down to those with rhabdome 5–6 μ thick and clads 8–12 μ long. The anatriaenes show a considerable tendency to vary. Thus spicules with three short rounded clads, which may be only 4 μ long, occur (pl. 48, fig. 4, *b*). Monaenes, larger than the common anatriaenes, occur; rhabdome 16 μ thick, clad 20 μ long and 16 μ thick (fig. 4, *c*). All the clads may be so degenerate that the spicule is virtually tylote at this end (fig. 4, *d*). Rarely the rhabdome is prolonged beyond the degenerate clads (fig. 4, *e*).

4. Sigmas. Abundant in the dermal membrane of the poriferous pits and between them, and in the cloacal wall; also abundant throughout the interior of the sponge, 12–16 μ long, of the usual shape.

Holotype.—Cat. No. 21314, U.S.N.M.

The species is close to *Tetilla* (*Cinachyra*) *mertoni*, Hentschel (1912, p. 332), from the Kei Islands, a form with larger pits that reach a diameter of 3 cm. In *T. mertoni* there are several cloacae, apparently very similar to the pits; the anatriaenes, while they have a flat cladome, are of a slender type and the spicules are apparently not confined to the root bundles. The protriaenes are slenderer, with larger clads, than in *T. paterifera;* they are also said to be less abundant than the anatriaenes. The sigmas in Hentschel's species have truncated or slightly dilated ends. The Philippine species also resembles, especially in external appearance, *Tetilla* (*Cinachyra*) *vaccinata* from the Indian Ocean, Dendy 1921*b* (p. 14). There are however skeletal differences and also differences concerning the oscula.

Genus CRANIELLA O. Schmidt (1870).

Craniella O. SCHMIDT, 1870, p. 66.—SOLLAS, 1888, p. 30.—TOPSENT, 1920*b*, p. 7.
Tethya LENDENFELD, 1903, p. 23.—LAMARCK part, LENDENFELD, 1906, p. 69.

The ectosome is differentiated into an inner fibrous layer, traversed more or less radially by cortical oxeas, and an outer collenchymatous layer excavated by subdermal cavities. Pores scattered over surface of sponge. Oscula distinguishable from pores and usually few in number. The microscleres have been lost in some species.

As to the propriety of the name *Craniella*, instead of *Tethya*, see *Donatia.* Lendenfeld, 1906, merges *Tetilla* (plus *Chrotella*) and *Craniella* (*Tethya*) because of the existence of forms intermediate in respect to certain features. I follow the common practice and maintain both genera (for some discussion of this matter, see George and Wilson, 1919, and previously under *Tetilla*). In the following list Lendenfeld's practice must be borne in mind.

Since Lendenfeld's Tierreich synopsis (1903) there have been described—

C. elegans Dendy, 1905, p. 95, Ceylon.

Tethya coactifera Lendenfeld, 1906, Kerguelen.

Tethya stylifera Lendenfeld, 1906, Kerguelen.

Tethya crassispicula Lendenfeld, 1906, Kerguelen.

Tethya armata Baer, 1906, Zanzibar.

Tethya sagitta Lendenfeld, 1907, p. 307, Antarctic.

C. disigma Topsent, 1904, p. 100, Azores.

C. sagitta Lendenfeld, var. *microsigma* Kirkpatrick, 1908, p. 1, Antarctic.

C. sagitta Lendenfeld, var. *pachyrrhabdus* Kirkpatrick, 1908, p. 4.

A few species assigned by Sollas and others to *Craniella* (*Tethya*) are inscribed by Lendenfeld, 1903, under *Tethyopsilla*.

CRANIELLA SIMILLIMA (Bowerbank).

Plate 40, fig. 1.

Tethea simillima part Bowerbank, 1873, p. 15.

Craniella simillima (Bowerbank), Sollas 1888, p. 30.

Tethyopsilla zetlandica (Carter) part, Lendenfeld, 1903, p. 31.

Station D5151, one specimen; D5164, one specimen; D5141, one specimen.

Sollas, 1888, discusses Bowerbank's description and type, and redefines the species as subspheroidal with terminal osculum and conulose surface; the conules absent over the base, here replaced by a general pilosity. Without microscleres. Sollas' specimens came from the Australian coast, the Philippines, and the vicinity of the Aru Islands. The largest measured 29 by 27 mm.

Lendenfeld, 1903 (p. 31), combines the species along with two others of Sollas' under *Tethyopsilla zetlandica* (Carter), a form from the neighborhood of the Shetland Islands, differing from the common Atlantic *Craniella cranium* in a negative character, the absence of sigmas. Hentschel (1911, p. 287; 1912, p. 331) accepts *T. zetlandica* in Lendenfeld's extended sense, and so designates two sponges, one from the Australian coast, one from the Aru Islands.

It seems to me desirable, for the present at least, to retain *C. simillima* as an Indo-Pacific form, in which the general surface is markedly conulose, while the base is pilose. Hentschel's sponges just referred to, one of which measures 5 cm. in diameter, would perhaps fall under *C. simillima*. In one, at any rate, the surface is distinctly conulose. For the other this character is not given.

In regard to the absence of sigmas, the feature on which Lendenfeld's Tethyopsillidae (1903, p. 29, deleted by Lendenfeld, 1906) and *Tethyopsilla* Lendenfeld (1903, p. 30) chiefly rest, it may be said that Sollas, 1888 (p. 55), looks on this character as a good specific difference. Topsent, 1904 (p. 99), would not assign to the feature even this value, and accordingly regards the specimens designated *Craniella zetlandica* (Carter) by Sollas as not separable from *Craniella cranium* (see Lendenfeld, 1906, p. 121). In the classification adopted in this report, *Tethyopsilla* Lendenfeld is not accepted, but the absence of sigmas is looked on as a specific difference, one that distinguishes for instance *C. simillima* from the Ceylon sponges designated *Craniella elegans* by Dendy (1905, p. 95).

The *Albatross* specimens of *C. simillima* are larger than have been recorded. One is ellipsoidal, 65 mm. high, 45 mm. wide. Another is spheroidal, 53 mm. in diameter. In the former there is a single terminal small osculum, in the latter four small oscula near the upper pole. The conules are sharp, 1–2 mm. high, frequently connected by ridges and often about 2 mm. apart. Papillae of the basal surface, very small, closely set elevations, appearing rounded to the eye. Sponge is heavy and compact, reddish-brown at the surface, lighter colored inside. One specimen is full of large bluish embryos, about 1,400 μ in diameter, in which the radial skeletal bundles have already formed.

The dermal membrane between the conules is riddled with pores which extend up on the conules. From these, short cylindrical pore canals, 20–60 μ in diameter, pass into the subdermal spaces of the outer ectosomal layer. The outer layer of the ectosome is commonly 200–500 μ thick between the conules, thicker than this where the conules are close together; nonfibrous, brownish, but without coarsely granular conspicuous cells. The inner or cortical layer of the ectosome is 1,200–1,800 μ thick, without pigment, fibrous, and is filled with the radial cortical spicules which often protrude into the outer estosomal layer and even reach the surface. In the extreme basal region of the sponge the whole ectosome is thicken than elsewhere.

The radial skeletal bundles coming from the center of the sponge pass in the usual way into and project from the conules, some of the spicules projecting several millimeters beyond the surface. The protruding spicules include protriaenes, anatriaenes, and some large oxeas, the bundles themselves being made up of these three classes of spicules.

The radial oxeas reach a size of 4 mm. by 50 μ.

The cortical oxeas measure 1,200–1,400 by 32–50 μ. Sollas says they are fusiform. I find them slightly inequiended, the inner end as usual being the finer one.

Protriaenes have a rhabdome about 5 mm. long, 12–18 μ thick above, then tapering to a hair-like thickness; clads 60–80 μ long, strong; cladomes projecting, or occasionally within the conulus but near the surface.

Anatriaenes have a rhabdome which may reach a length of 10 mm., 8–15 μ thick above, then hair-like; clads 40–60 μ long. These spicules very abundant in the bundle; some cladomes projecting, but most in the ectosome, those of younger spicules in the outer part of choanosome.

The specimen from D5141 is very different from the other two. From the similarity in skeleton I conclude that it is probably a young form of the same species. It is pyriform, 19 mm. high, with a faintly papillose surface, the papillae supported by the radial bundles. The upper rounded end appears to the eye to be without projecting spicules, the lower half showing such spicules, which however only protrude a short distance and do not form a root tuft.

Brown granular cells are abundant in the ectosome, and the specimen differs from the preceding also in the following skeletal measurements:

The cortical zone of the ectosome is only 700 μ thick in the upper part of the sponge, 1,100 μ thick below. The larger radial oxeas are only about 2 mm. by 24 μ. The cortical oxeas are about 700 by 20 μ.

The protriaenes are small; the rhabdome only 8–12 μ thick, the clads 40–60 μ long. These spicules barely project or do not project in the upper half of the sponge. They are more abundant and they project freely in the lower half.

The anatriaenes are also smaller than in the other two specimens, although they have the same shape and show the same abundance and arrangement. The rhabdome is about 7 μ thick above, the clads 40 μ long.

Genus PARATETILLA Dendy (1905).

Paratetilla Dendy, 1905, p. 97.

With a special layer of modified triaenes in the ectosome or at the junction between ectosome and choanosome. The triaenes may depart from the ortho- or plagiotriaene type only in having a very short rhabdome; or they may depart in various ways, becoming irregular and lacking uniformity in one and the same sponge. Some species with, some without, special poriferous depressions.

PARATETILLA ARCIFERA, new species.

Plate 40, fig. 2; plate 48, fig. 6.

Station D5400, one specimen.

Sponge subglobular, both upper and lower surfaces flattened. Horizontal diameter about 30 mm. Shelly incrustations conceal a considerable part of the surface, and on one side the body has been torn badly.

In the equatorial zone are deep poriferous pits, with smooth lining membrane and without marginal fringes. The lining membrane shows small closely set pore areas separated by narrow trabeculae. The cavities underlying the membrane are no larger than the subdermal cavities of the general surface, a fact which tends to indicate that the pits are afferent. In the specimen there are two perfect pits and parts of two others. The largest has an equatorial width of 14 mm., the others about half that.

A small, very eccentrically placed osculum, about 1 mm. in diameter, in a depressed smooth area, is present on the upper surface. Perhaps other oscula were present in the torn region.

The ectosome is not distinctly fibrous. There is a fairly extensive system of subdermal cavities, from which narrow canals pass into the interior, and into which small pore canals pass everywhere from the dermal surface. The abundance of sigmas in the walls aids in tracing the pore canals.

The under surface was doubtless attached in places and was torn loose from its substratum. Nevertheless the dermal membrane over a large part of it is uninjured. This surface is very different from the rest, which is much incrusted with sand grains, etc., and is hispid with the projecting spicules of the radial skeletal bundles. The under surface, on the contrary, has a smooth, clean, thin dermal membrane showing small pore-areas separated from one another by a net-work of narrow trabeculae. It is quite similar to the membrane lining the poriferous pits.

The skeletal bundles pass radially outwards to all parts of the sponge from about the center of the lower surface, the lowermost bundles lying lengthwise at this surface in plain view. Doubtless the detailed character of the lower surface varies in accordance with the local conditions affecting the individual.

Spicules (pl. 48, fig. 6).—1. Oxea, equiended, 3.5 mm. by 50 μ, with smaller sizes. The chief spicule of the radial bundles, the more superficial ones projecting from the surface.

2. Oxea, small and slender, about 360 by 2–3 μ; scattered, not very abundantly, between the skeletal bundles.

3. Orthotriaene with short rhabdome; the characteristic ectosomal spicule; abundant. Typically the rhabdome is radial to the surface, the clads tangential; the spicules forming one to about three layers. In a typical spicule the rhabdome measures 120 μ, the clads 370 μ in length; larger and smaller sizes occur; rhabdome in general about one-third the length of a clad. Rhabdome straight, tapering to a point, or more cylindrical. Clads with the usual bowlike curvature; those of a spicule generally alike.

A few reduced orthotriaenes occur. Clads and rhabdome all about equal in size, 60–100 μ long, all straight and cylindrical.

4. Anatriaene. Abundant in the radial bundles. Cladomes for the most part grouped near the surface, some farther out almost at the surface; a few projecting. Rhabdome 3–4 mm. long, 6 μ thick near cladome, then becoming hair-like. Cladome rather shallow, clads 40–48 μ long.

5. Protriaene. Present over the general surface in the radial bundles, but few in number; some with cladomes below the surface, some with cladomes projecting. Rhabdome 3.5–4 mm. long, 8–12 μ thick near the cladome, somewhat thicker below, and then tapering to a hair-like thickness in the usual way. Clads 50–70 μ long.

Bundles of the under surface include a considerable number of protriaenes, larger than those of the rest of the body and for the most part projecting. Rhabdome reaching 14 μ in thickness, clads 120 μ in length.

6. Sigmas, about 16 μ long, of the usual shape. Abundant in the dermal membrane, including the general and lower surfaces and the lining of the poriferous pits. Very abundant in the canal walls, but absent or only scantily present in the tissue between the canals.

Holotype.—Cat. No. 21278, U.S.N.M.

Dendy, 1905 (p. 97), established this genus for a new form, *P. cineriformis*, from Ceylon, in which the modified triaenes are irregular, and an old form, *P.* (*Tethya*) *merguiensis* (Carter), in which Sollas (1888, p. 16, *Tetilla merguiensis*) had shown that these spicules were only orthotriaenes with short rhabdome.

Lindgren, 1898 (p. 328), had already merged *Tetilla merguiensis* in *Tetilla* (*Stelletta*) *bacca* (Selenka), in which the ectosomal megascleres are plagiotriaenes with reduced rhabdome; all four rays usually about equal and straight.

Thiele, 1900 (p. 39), followed Lindgren in this matter of synonymy, and further classed several of Kieschnick's names (1896, 1900) as synonyms of *T. bacca*—namely, *T. ternatensis*, *T. amboinensis*, *T. violacea*, and *T. rubra*, the first from Ternate, the others from Amboina.

Lendenfeld, 1903, adopted the synonymy of *T. bacca* upheld by Lindgren and Thiele, except that he separated from this species two of Kieschnick's forms, *T. amboinensis* and *T. rubra*, which he combined and transferred to *Cinachyra* (*C. amboinensis*). While *T. merguiensis* is perhaps a synonym of *T. bacca*, Lendenfeld is justified in retaining *T. amboinensis* Kieschnick as a distinct species, since it has poriferous pits (Kieschnick, 1900), and these are not definitely recorded for *T. bacca*, although Dendy, 1921*b* (p. 21), would interpret the apertures in Selenka's type (*Stelletta bacca*) as such. Lendenfeld's treatment, at the moment, seems to be the safer.

The *Albatross* sponge is evidently close to Kieschnick's species, which Hentschel has more recently (1912, p. 331, *Cinachyra amboinensis*) recorded from the Aru Islands. Hentschel calls the ectosomal spicules orthotriaenes, and says the rays vary in shape and length. Kieschnick's type was ovoidal, blue gray, with an apical osculum and small cloaca; root tuft at the lower end; poriferous pits; the ectosomal megascleres varying from regular "Vierstrahler" (calthrops) to "modifications of an ordinary triaene" (his figures are not decisive in this matter). The *Albatross* sponge differs too much from this in habitus, and especially in the character of the ectosomal triaenes, to be identified as the same species.

Under the genus we may then record, to date: *Paratetilla bacca* (Selenka), *P. amboinensis* (Kieschnick), *P. cineriformis* Dendy, *P. excentrica* Row (1911, p. 306), a form in which the ectosomal triaenes are very irregular, and the species here described. Dendy, it should be added, who has recently (1921*b*, pp. 21–25) studied a number of specimens from the Indian Ocean, would follow Thiele's practice and accept *P. bacca* as a comprehensive variable species to include all that Thiele (see above) put into it and also his own *P. cineriformis* and *P. eccentrica* Row. Within this species he retains one of Kieschnick's names as a variety, var. *violacea*, and establishes a new variety, *corrugata*, in which the very numerous poriferous pits (porocalices) tend to become confluent.

The sponge from Amboina designated by Topsent, 1897, p. 437, *Tetilla merguiensis*, since it has amphitriaenes, would appear to be a distinct species referable to *Amphitethya* Lendenfeld. This is certainly a more objective treatment than to interpret the amphitriaenes as abnormalities.

Likewise *Paratetilla aruensis* Hentschel, 1911 (p. 329), is referable to *Amphitethya*, although Dendy has recently (1921*b*, p. 21) expressed the opinion that it may be left in *Paratetilla*. Hentschel, it should be added, would merge the two genera, while Dendy thinks they may be kept separate.

The remaining genera of the family are not represented among the sponges studied. They are defined and discussed below.

Genus CINACHYRA Sollas (1886).

Cinachyra Sollas, 1886, p. 183; 1888, p. 23.—Part, Lendenfeld, 1903, p. 26.—Part, Dendy, 1921*b*, p. 11.

The ectosome is a fibrous cortex traversed by radial cortical oxeas. Poriferous depressions with sphinctrate mouths are present. In some species there are also simple oscula.

Sollas, 1888, regarded some of the poriferous depressions as afferent, others efferent. The facts as a whole confirm, I think, this interpretation. Nevertheless Kirkpatrick has (1905) found simple oscula, or oscular eminences, over the upper surface of *C. barbata* Sollas. Kirkpatrick reviews the species and thinks probably the records are deficient and the species all have simple oscula like *C. barbata*. It is difficult to believe that this is universal (see *Tetilla crustata* of this report), unless indeed, as I have suggested (under *Tetilla crustata*, var. *aperta*), one and the same poriferous depression may in a different physiological state of the individual come to appear as a simple cloaca or as the terminal part of a main efferent canal.

Some of the species enrolled by Lendenfeld, 1903, and Dendy, 1921*b*, under *Cinachyra* fall under *Tetilla* according to the classification followed in this report. Kirkpatrick (1905 p. 666) indeed judges from the records that in only one of these species, *C. barbata*, is there a fibrous cortex " with a dense palisade of oxeas."

Since the Tierreich synopsis (Lendenfeld, 1903) Lendenfeld (1906, 1907), Hentschel (1911, 1912), Kirkpatrick (1908), and Dendy (1921*b*) have recorded a number of new forms under *Cinachyra*. They all fall under *Tetilla* (*Cinachyrella*) as used in this report. Dendy, 1921*b*, discusses the differential features of the species which he groups under *Cinachyra* and gives a useful key.

Genus AMPHITETHYA Lendenfeld (1906).

Amphitethya LENDENFELD, 1906, p. 126.

With microscleres, without vestibular poriferous depressions, with amphiclads (amphi- triaenes, -diaenes, -monaenes).

Lendenfeld, 1906, under this head combines with a new species, *A. microsigma*, some old ones previously described under Tetilla.

Among these is *Tetilla* (*Tethya*) *stipitata* (Carter), in which the characteristic generic spicules, amphitriaenes, " very variable in form and size " and sometimes " reduced to simple triaenes," occur in the basal (stem) part of the sponge (Sollas, 1888), and which therefore fits well in the genus. In Lendenfeld's species, *A. microsigma*, amphitriaenes, connected by transitional forms with plagiotriaenes, occur and also only in the stalk.

Lendenfeld also lists here somewhat provisionally *Tetilla* (*Tethya*) *bacca* (Selenka). The synonymy of *T. bacca* is confused, as Dendy has said (1905). Lendenfeld, 1903, following Lindgren and Thiele, combined under this head several sponges, among them the sponge from Amboina described by Topsent (1897) as *Tetilla merguiensis*. This sponge has amphitriaenes and is accordingly referable to *Amphitethya*. In the other sponges combined by Lendenfeld under *T. bacca*, amphitriaenes are not recorded; these sponges are assignable to *Paratetilla*. It thus comes about that *T. bacca* is mentioned by Dendy, 1905, under *Paratetilla*, and by Lendenfeld under *Amphitethya*.

Hentschel, 1912, deletes *Amphitethya*, making it synonymous with *Paratetilla;* but, as far as the records enable one to judge, the two genera represent different character-combinations, and both should be retained. *Paratetilla aruensis* Hentschel, 1912 (p. 329), which has amphitriaenes, thus becomes *Amphitethya aruensis.*

Genus FANGOPHILINA O. Schmidt (1880).

Fangophilina O. SCHMIDT, 1879–80, p. 73.
Spongocardium KIRKPATRICK, 1902, p. 224.

With microscleres, with two unlike vestibular spaces or poriferous depressions, of which one belongs to the incurrent, and one to the excurrent system.

O. Schmidt's *Fangophilina submersa*, from the Caribbean, was tentatively placed by Sollas, 1888, along with *Cinachyra.* Lendenfeld, 1903, classed it with that genus. Kirkpatrick, 1905, and Lendenfeld, 1906, regard *Fangophilina* as a good genus, of which *Spongocardium* is a synonym. The genus includes in addition to *F. submersa* O. Schmidt, *F.* (*Spongocardium*) *gilchristi* Kirkpatrick, 1902 (p. 224), and *F. hirsuta* Lendenfeld, 1906 (p. 157).

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Under *Tethyopsilla* (Lendenfeld, 1888), Lendenfeld (1903) groups along with his type, *T. stewartii*, a number of species assigned by Sollas and some others to *Tetilla* and *Craniella.* Dendy has suggested that the genus, characterized by the absence of microscleres, is an artificial (polyphyletic) one. It seems clear that microscleres are sometimes lost. The genus, in the classification followed in this report, is deleted and the species distributed. Hentschel (1911, 1912), however, uses it, as does Baer (1906).

Topsent (1913*b*, p. 14) would group certain of the species referred by Lendenfeld to *Tethyopsilla* under a new genus *Craniellopsis.* These are the species which resemble *Craniella* in possessing cortical oxeas. They are *C. infrequens* (Carter), *C. zetlandica* (Carter), and *C. lentiformis* (Thiele). To them Topsent adds *C. azorica*, new species, from the Azores. Some would doubtless prefer, with the writer, to set off these forms from *Craniella* as a subgenus, it being understood that such a subgenus, based on a single character, will include forms in which the character has been acquired by analogical variation and between which therefore the genetic relationship is not especially close.

Suborder HALICHONDRINA.

Halichondrina VOSMAER 1887; RIDLEY and DENDY, 1887; and AUTHORS.

Megascleres all monaxonid. Skeleton very commonly reticulate or fibrous, with a good deal of spongin. Microscleres, when present, either sigmas or derived forms such as chelas.

Family HAPLOSCLERIDAE.

Haploscleridae Topsent 1894*c*; and Authors.

Haploscleridae minus *Hamacanthinae* and *Merliinae* Dendy, 1921*b*.

Microscleres often absent; when present never chelas. The megascleres are fundamentally diactinal. Where the skeleton is made up of distinct spiculo-fibers, these are typically non-plumose.

The family is taken in the sense of Topsent (1894*c*), except that the Phoriosponginae are excluded. The subfamilies recognized are the four (Gelliinae, Renierinae, Chalininae, Spongillinae) advocated by Topsent, 1904, and the Phloeodictyinae. The forms making up the subfamilies Tedaniinae, Desmacellinae, and Hamacanthinae were transferred by Topsent, 1894*c*, to the Desmacidonidae as forms which have lost the chelas. The general complexity of these sponges seems to justify this move which has been followed by Topsent in later papers, by Wilson, 1904, and Hentschel, 1912, for *Tylodesma* (*Biemma* Authors), by Hentschel, 1911, for *Desmacella*, by Kirkpatrick, 1908, Lundbeck, 1910, and Hentschel, 1911, 1912, for *Tedania*, and by Dendy, 1921*b*, for *Tedania* and the *Desmacellinae*. Dendy, 1905, added a new subfamily: Heteroxyinae, for *Acanthoxifer*, new genus, and *Heteroxya* Topsent, the latter referred by its author and in this report to the Donatiidae (Tethyidae Authors). Row (1911) contributed a new genus, *Anacanthaea*, to this subfamily which Dendy, 1921*b* (p. 25), now transfers to the Desmacidonidae. (See this report under Spongosorites.)

Dendy has (1916*b*) proposed to merge the Axinellidae in this family, but more recently would regard the bulk of the Axinellidae as reduced Desmacidonidae (1921*b*, p. 111). Lundbeck in his important memoir (1902) prefers not to use the family, but holds to the Homorrhaphidae and Heterorrhaphidae of Ridley and Dendy (1887).

Subfamily GELLIINAE.

Gelliinae Ridley and Dendy, 1887.

The megascleres are diactinal, oxeas, or strongyles; with microscleres in the shape of sigmas, toxas, rhaphides or trichodragmas or microxeas, separately or in various combinations.

The group (Gelliadae part, Gray, 1872) is taken in the sense of Ridley and Dendy (1887) and Dendy (1905). Lundbeck, 1902, and Topsent, 1904, include *Oceanapia*, assignable to the Phloeodictyinae. The group is thought by Dendy to include the most primitive sponges of the family, from which others (Renierinae, Chalininae, for example) without microscleres have been derived.

Genus GELLIUS Gray (1867).

Gellius GRAY, 1867, p. 538.—RIDLEY and DENDY, 1887, p. 37.

Gelliinae in which the skeleton is typically a renieroid network without fibers. But spicule tracts may also be present, or indeed may replace the simple renieroid network. The latter in some species becomes very irregular and halichondrioid. Spongin is scanty. When spicule tracts are present, they are not sharply defined fibers as in Gelliodes.

Gellius, in which Gray (1867) gave the skeleton as "regularly netted," has been defined by Ridley and Dendy, 1887, Topsent, 1894*c*, and Lundbeck, 1902, as without distinct fibers or at any rate without long fibers. But compact spicule tracts, including a little spongin, which are not far from the fibers of many Gelliodes species, are found in *Gellius flagellifer* Ridley and Dendy (1887), *Gellius perforatus* Wilson (1904), and in some other forms.

The megascleres in the genus are characteristically oxeas, but there are species with strongyles (Lindgren, 1898). Lundbeck, 1902 (p. 71), sums up the combinations of microscleres occurring in the genus as follows: Sigmas; sigmas and toxas; sigmas and rhaphides separately or forming trichodragmas; rhaphides (trichodragmas); toxas. He would merge *Rhaphisia* Topsent (megascleres—oxeas; microscleres—rhaphides or trichodragmas, or trichodragmas and toxas). The number of species is growing so that some subdivision, even if artificial, based on the microscleres, would be useful.

The distinction between the group of species constituting *Gellius* and that constituting *Gelliodes* is vaguer than is sometimes assumed (Dendy thus, 1905, p. 137, defines *Gelliodes* as having fibers with abundant spongin), and a brief discussion of the latter genus may not be out of place here.

Gelliodes Ridley (1884, p. 426) may be defined: Gelliinae in which the skeleton includes, sometimes in addition to a finer network or a more scattered skeleton, *sharply defined fibers* forming a reticulum, which in some species is produced by the dendritic branching and anastomosing of longitudinal fibers. Spongin may be abundant, in which case the fiber is cored (Chalina-like) by the spicules, or scanty, in which case the fiber is a mere column of spicules (Petrosia- or Pachychalina-like) cemented together, but the column not covered, by spongin. Microscleres—sigmas, or sigmas with toxas.

Lundbeck, 1902 (p. 75), has materially helped in the progressive definition of Ridley's genus. In the type species (Ridley, 1884, p. 426) and in some other species, those described by Lundbeck (1902) and in *G. petrosioides* Dendy (1905, p. 138), for instance, spongin is very scanty, and yet the fiber has a distinctness which is absent from our concept of Gellius, toward which the genus shades over. Some rearrangement of the species of the two genera, to avoid overlapping is probably already desirable.

As Lundbeck, 1902 (p. 78), says, since sigmas and toxas occur together in the new species which he describes, Dendy's earlier suggestion, that it may prove necessary to merge *Toxochalina* (with toxas), might now be followed. But, as he intimates, it would be better to keep the two genera separate by stressing the regular, chalinid, arrangement of the skeletal fibers in *Toxochalina* in contrast to the more irregular arrangement which is on the whole characteristic of *Gelliodes*. And yet in some species (type species, for example, Ridley, 1884) of the latter, radial fibers and connectives are distinguishable. We here meet again the common phenomenon of the intergradation of a group of species with *several* other such groups, the explanation of which seems to be that the characters of the ancestral group have varied during the evolution of the existing species independently of one another, and thus numerous combinations of characters have resulted.

GELLIUS VARIUS (Bowerbank), var. FIBROSA, new variety.

Plate 40, fig. 3; plate 49, fig. 1.

Halichondria varia Bowerbank, 1875, p. 292.
Gellius varius Ridley, 1884, p. 424.

Bowerbank's name of *Halichondria varia* (1875, p. 292) was given to several specimens from the Straits of Malacca, in which the body was in some cases a rough irregular mass and in others consisted of short cylindrical branches; with renieroid skeletal network, uni- or bi-spiculous; with unispiculous dermal network. Ridley (1884, p. 424) states that in this type the oxeas measure 220 by 16 μ, the sigmas 25 to 32 μ long.

With this species Ridley (1884) combined *Isodictya virgata* Bowerbank, also from Straits of Malacca (Bowerbank, 1875, p. 294). The sponge so named consisted of two branches, not exceeding 2 inches in height. The renieroid skeletal network shows well-pronounced multispiculous primary (namely, radial) lines. Ridley gives the oxeas as measuring 220 by 14 μ, the sigmas 25 μ long.

Ridley (1884) had two fragments from Port Darwin; of an erect, cylindrical habitus; dimensions not given. In these the oxeas measured 250 by 15 μ, the sigmas 19 μ long. Ridley and Dendy (1887, p. 38) had several fragments from the Philippines, all more or less cylindrical, the largest 80 mm. long by about 6 mm. in diameter. The pieces branch and the branches show a strong tendency to anastomose. The size and distribution of the oscula are as in the *Albatross* specimen. The oxeas measure 220 by 13–14.5 μ, sigmas about 40 μ long.

Two dried specimens of the *Albatross* collection are assignable to this species, one from station D5626, the other from Togian Bay, Togian Island, Gulf of Tomini, Celebes; also two alcoholic specimens from Togian Bay. They differ, however, from the records in a marked anatomical feature—namely, the possession of strong longitudinal spicule-tracts—and may on that account be referred to a variety, *fibrosa*, new variety. The sponges are much taller than those recorded, the oxeas considerably smaller, and the sigmas are at the lower limit of the range recorded, which is considerable.

Sponge body consists of a branching axis, which may be cylindrical, or distinctly flattened, the branches often meeting and fusing and terminating in pointed extremities. Where the sponge is more cylindrical the diameter is 5–7 mm. In one of the typical flattened regions the diameters are 20 mm. and 7 mm. Total height reaches 300–400 mm. Sponge firm but brittle; color of dried sponge, light gray or light yellowish brown; color of alcoholic specimens, reddish brown. The photograph, (pl. 40, fig. 3), shows a very flattened piece, a moderately flattened piece, and a terminal cylindrical branch, side by side, all from a dried specimen.

Pores are closely and uniformly distributed over the surface in the meshes of the dermal reticulum. Abundant small afferent canals, about 0.5 mm. in diameter, extend in radially from the surface and give the sponge a porous appearance. Oscula about 2 mm. in diameter are abundantly scattered over the surface, leading into well-marked depressions into which several efferent canals directly debouch.

The skeleton is made up of a renieroid reticulum and longitudinal polyspicular tracts, often compact enough to deserve the name of fibers, 20–100 µ in diameter. They consist of closely packed spicules in about 3 to 12 rows; they branch and anastomose obliquely so as to form a coarse and rather vague network with elongated meshes. The longitudinal tracts were conspicuous in all the sections made, but are considerably more abundant and closely set in some regions than in others. They are especially developed in, though by no means confined to, the axial part of the sponge. Thus in a typical region where the total diameter of the sponge is 7 mm., the longitudinal tracts occupy an axial portion about 4 mm. wide. Their distribution varies however in the same specimen (perhaps with the age of the region), and a considerable number may occur in the superficial part of the body. Indeed, in some sections in which they were rather sparsely present, the tracts were quite as abundant in the peripheral as in the axial part of the body.

The rest of the skeleton is in general made up of a renieroid reticulum, with 4 or 3 sided meshes, the side about the length of a spicule and formed by one or sometimes two spicules (pl. 49, fig. 1).

In this reticulum the spicules are so arranged as to form fibers or lines that are radial to the surface (*r. f.*) There is the usual variation, however, and in the dried specimen from Togian Bay, while the radial fibers are commonly 1–2 spicules thick, they are sometimes thicker, up to about 4 spicules. In the same specimen, the connectives between the radial fibers, while they commonly have the length of a single spicule (pl. 49,, fig. 1, *c*) may be twice as long; and, while as a rule only one or two spicules thick, they may range up to a thickness of 4 spicules. The dermal reticulum is merely the outermost part of the skeletal reticulum, the meshes 4 or 3 sided, the side formed usually by one spicule. In both skeletal and dermal reticulum, spongin is scanty, only conspicuous in the angles. In several parts of the Togian Bay specimens single spicules, or bunches of two, radiate outward from the nodes of the dermal reticulum.

The longitudinal tracts are connected with the finer reticulum. In transverse sections of the sponge they may be seen to meet the reticulum at points (nodes) where several spicules come together.

The oxeas, smooth, slightly curved, evenly tapering at both ends, measure 160–180 by 8–9 µ; sigmas 18–20 µ long, abundant in the interior and dermal membrane.

Holotype.—Cat. No. 21329, U.S.N.M.

GELLIUS ANGULATUS (Bowerbank), var. VASIFORMIS, new variety.

Plate 40, fig. 4.

Halichondria angulata Bowerbank 1866, p. 233; 1874, p. 101.

Gellius angulatus (Bowerbank) Ridley and Dendy, 1887, p. 44.—Topsent, 1892, p. 76; 1904, p. 231.—Lundbeck, 1902, p. 63.

This North Atlantic species is a massive, apparently small, sponge; main skeleton is a rather irregular renieroid reticulum, occasionally multispicular; dermal reticulum unispicular. Ridley and Dendy give the spicular dimensions as follows: oxea 290–340 by 9–10 µ; toxa 80 by 1 µ; sigma 19 by 1 µ. Topsent (1904) in some of the specimens from the Azores finds the oxeas unusually large, 530–550 by 9–13 µ; the sharply angulated toxas 73 µ long; sigmas 17 µ long.

Dendy (1905, p. 136) refers a small massive Ceylon sponge to a variety (*canaliculata*, new variety) of this species. Main skeleton a unispicular reticulum; dermal skeleton composed of scattered oxeas placed tangentially. Oxea about 250 by 8–10 µ; toxa, shorter and stouter than in the type, sharply angulated in the middle, up to 44 µ in length; sigma, simply contort, about 28 µ long. Surface of sponge shows ramifying canals just beneath dermal membrane, running to oscula of moderate size at one end of body.

A partially macerated specimen from station D5162 is referable to this species and because of its vasiform habitus may be given a varietal name.

The sponge is a thick-walled vase, tapering below to a small attached base. An axial cloaca, extending throughout the body, opens on the upper end by a large osculum. Total height 125 mm.; diameter 60 mm. Diameter of osculum 25 mm.; cloaca in its upper part as wide as the osculum, diminishing below. Sponge firm but slightly compressible; light brown in color.

The dermal membrane has macerated away. The outer surface shows abundant small apertures, mostly 1 mm. or less in diameter, leading into more or lesss radial canals of corresponding size. A large hole, 20 by 12 mm., on the side of the sponge, perforates the wall and leads into the cloaca—probably the result of an injury. A considerable part of the lining of the cloaca is uninjured. This is smooth and shows no apertures. Just beneath it are a good many canals, 3 mm. and over in diameter, which perhaps open into the upper part of cloaca where the lining has been lost. Sponge tissue in general dense; canals, except those just referred to and a few others, 1 mm. or less in diameter.

Skeleton a unispicular reticulum with a little spongin at the nodes; meshes triangular, squarish, or polygonal; side of mesh 70–190 µ long and therefore less than the length of a single spicule.

Spicules.—1. Oxea, smooth slightly curved, gradually pointed as in the type, not abruptly as in variety *canaliculata*, about 240 by 9 µ.

2. Sigma, slender, simply contort, 16–20 µ long; abundant. A few larger forms, up to 68 µ in length, were observed. It is uncertain if they belong to the sponge.

3. Toxa, fairly stout, sharply angulated in the middle; not at all common. Specimens measured 28, 32, 40, 52, 68 µ in length; the small forms, 28–32 µ, are the more abundant.

Holotype.—Cat. No. 21264, U.S.N.M.

Genus STRONGYLOPHORA Dendy (1905).

Strongylophora DENDY, 1905, p. 141.

Meglascleres are strongyles of various sizes together with, in some species, oxeas. Megascleres partly collected in spiculofibers and tracts, with but little spongin; these forming a reticulum. A dense cortical layer of the skeletal reticulum may be differentiated. Microscleres in the form of smooth microxeas, chiefly or exclusively found in the dermal membrane.

I have slightly altered Dendy's original diagnosis (1905, p. 141), to cover the facts presented by the species to be described.—Topsent's new genus, *Microxina* (1917, p. 72), is placed by its author close to *Strongylophora*.

STRONGYLOPHORA CORTICATA, new species.

Plate 40, fig. 7; plate 48, figs. 2, 7.

A dried specimen, taken at station D5593. Sponge body consists of a branching axis, cylindrical or more often flattened, the branches anastomosing so as to give rise to an irregular mass. Transverse diameters of sponge: In a cylindrical region, 25 mm.; in a somewhat flattened region, 45 and 30 mm.; in a very flattened, laminate, region, 100 and 30 mm. Total height of sponge 405 mm.; greatest width 200 mm. Sponge has a distinct rind about 1 mm. thick, much firmer than the interior, which in the dried specimen is loose and fragile.

Oscula 5 to 10 mm. in diameter scattered over surface, each leading into a depression into which numerous smaller canals open. A fine dermal skeletal reticulum extends over whole surface, excepting the oscula which are open. Fleshy part of dermal membrane macerated.

The firm part of the rind consists of a dense subdermal lamella about 0.5 mm. thick, made up of closely packed megascleres, and perforated by rounded apertures (= radial canals), 250–350 μ in diameter. The parts of the lamella between the apertures measure 175–250 μ in width. The lamella is doubtless to be looked on as a close reticulum of dense spiculo-fiber. Between the subdermal lamella and the superficial (dermal) skeletal reticulum is a space crossed by radial pillars made up of the large megascleres. Between the pillars lie subdermal chambers, for the most part 250–350 μ wide; pillars narrow as compared with the chambers, often about 85 μ wide at the middle. In places where the sponge body has been cut across, a second skeletal lamella like the subdermal one may be seen in the inner parenchyma; more or less parallel to the surface of sponge but joining the subdermal lamella at an angle.

Skeleton of interior, internal to the subdermal lamella, made up of an irregular reticulum and scattered megascleres. The reticulum is composed of dense spiculo-fibers, up to 200 μ thick, and less compact spicule-tracts, grading down to bands 1–2 spicules thick. Dermal skeletal reticulum in general polyspicular; meshes 100–200 μ in diameter; sides of meshes formed by loose tracts of a few megascleres or occasionally by single spicules. Abundant radial tufts of very small oxeas, microxeas, project outwards from the strands of the dermal reticulum, not only from the nodes but from the sides of the meshes.

Spicules.—1. The dominant spicule is a strongyle (pl. 48, fig. 2,*a*), 260–315 by 18–22 μ, smooth, slightly curved, with evenly rounded ends. Smaller sizes are common, grading down through all sizes to small and relatively very stout forms (pl. 48, fig. 7,*a*), as small as 30 by 9 μ. Small strongyles of a slender type (fig. 7,*b*), 30–40 by 3–5 μ, also occur.

2. Oxeas (pl. 48, fig. 2,*b*) smooth, slightly curved, with sharp points, 220 by 12 μ, with many smaller sizes grading down to the microxeas, are common. The form is sometimes (rarely) that of the style.

3. Microxeas (pl. 48, fig. 7,*c*), smooth, slightly bent in the middle (angulated), 30–32 by 2–3 μ, common, especially in the dermal membrane but also in the interior. Nearly straight forms (fig. 7, *e*) are also abundant. The stylote form (fig. 7, *d*) of this spicule also occurs. If we assign the spicule to the group of microscleres, it is only because of convenience of description. For it is connected with the larger oxeas by intermediate spicules of all sizes, which occur abundantly. For such intermediate oxeas the following measurements may be recorded: 180 by 10 μ, 160 by 10 μ, 124 by 7 μ, 100 by 7 μ, 80 by 5 μ, 60 by 4 μ, 40 by 4 μ.

4. A good many slender curved oxeas, 40–50 by 1–2 μ, are found in the interior, some of which might be described as toxas (fig. 7, *f*.) The curvature varies: some are bent considerably more than others. The characteristic double curvature of the toxa is occasionally acquired, but more often it is only approached, as in the spicules figured where the ends of the bow are nearly straight, not recurved.

The spiculo-fibers, skeletal tracts, and skeletal lamellae, are composed chiefly of the large strongyles, with other megascleres intermingled. The dermal reticulum is made up, in addition to the radial tufts of microxeas, of large and medium sized oxeas overlying large strongyles. Spongin, although scanty, is present in the spiculo-fibers and tracts, as is well seen in fragments treated with potash for a minute, just long enough to free the spicules of a fiber from one another and from the spongin.

Holotype.—Cat. No. 21331, U.S.N.M.

The genus *Strongylophora* was founded by Dendy (1905, p. 141) for a sponge, *S. durissima*, taken in the Ceylon seas. Dendy's sponge apparently has no rind, although toward the surface the skeletal reticulum becomes more regular. Thiele (1903, p. 938) has described a sponge from Ternate, to which he gives the name of *Petrosia strongylata*. The spicules are substantially like those of *S. durissima* and the *Albatross* species, and the sponge should be brought under Strongylophora.

Dendy (1905) rather doubtfully places his genus in the Gelliinae, where it may be left for the present. Nevertheless the structure of the rind in the species here described is close to that of *Coelosphaera* (comp. *C. toxifera* of this report). In both the characteristic portion is a dense fenestrated lamella about 0.5 mm. thick. This resemblance may, to be sure, be only a case of convergent evolution, but it is so striking that I was induced to look very carefully for chelas in the *Strongylophora* species, but could find none. In looking for the chelas, however, the toxa-like oxeas (*see previously*) were noticed, and search showed that there were a good many of them in the sponge. Thus a second point of resemblance, of the kind that might be expected to occur in a related species, exists. Resemblances are scattered however, for in *Phloeodictyon fistulosum* there is a feature which constitutes a point of resemblance between the Phloeodictyinae and *Strongylophora*. In *Phloeodictyon fistulosum* namely, as noted by Topsent (1904, p. 236), the dermal skeleton includes not only oxeas like those of the main skeleton (300–330 by 10–12 µ), but much smaller forms also (80–100 by 3–5 µ). Ridley (1884, p. 420) also refers to this fact.

Subfamily RENIERINAE.

Renierinae Ridley and Dendy, 1887.

Megascleres, oxeas, or strongyles varying occasionally to styles. Skeleton reticulate, or the spicules may be scattered without definite arrangement. Spongin absent or present in small amount; only exceptionally does it envelop the spicules. No microscleres.

The group (Renierinae part, O. Schmidt 1870) is taken in the sense of Ridley and Dendy (1887) and Dendy (1905). Lundbeck, 1902, Kirkpatrick, 1902, Thiele, 1903, and Topsent, 1904, include *Phloeodictyon*, assignable to the Phloedictyinae.

Genus HALICHONDRIA Fleming (1828).

Halichondria Fleming, 1828, p. 520.—Vosmaer, 1887, p. 336.—Ridley and Dendy, 1887, p. 1.—Lundbeck, 1902, p. 16.

Renierinae in which the spicules are irregularly scattered, not forming a permanently fixed reticulum, sometimes aggregated to form tracts; with very little or no spongin. Spicules: oxeas, rarely strongyles.

The place of this genus in the classification has commonly been looked on as an assured one. But Topsent has in recent years (1911) pointed out that the ciliated larva differs from that of the Renierinae and proposes a new classification in which *Halichondria* and *Reniera* are widely separated.

HALICHONDRIA PANICEA Johnston.

Halichondria panicea Johnston, 1842, p. 114.—Ridley and Dendy, 1887, p. 2.

To this species two specimens from station D5218 are referable. One is an amorphous mass 60 mm. in diameter with oscula that are not raised or only slightly raised above the surface. The other is elongated horizontally, branched at one end, 80 by 30 mm., with four oscula, all at the ends of short oscular lobes or prominences. A third specimen, broken, from station D5447, resembles the latter in respect to the oscula. Color, light yellowish brown.

The dermal membrane is the usual sieve membrane, perforated everywhere by closely set pores. It is, where perfect, well lifted up above the subjacent tissue, as if the sponges had been killed when thoroughly expanded. Beneath it narrow trabeculae of denser tissue are rather vaguely seen. If now the dermal membrane should sink down, in a sponge losing water, upon the trabeculae, the effect of a reticulum, formed by the trabeculae and embracing pore areas, would be produced. Bowerbank (1866, p. 230) refers to this appearance of the surface in dried specimens. Tangential, narrow subdermal canals are present in some abundance but they are not conspicuous. Doubtless with respect to them, also, the physiological state of the sponge (contracted or expanded) would materially alter the appearance of the surface.

The spicules of the interior are thickly strewn in all directions in the usual irregular way. Tracts, as distinct from the general mass of spicules, are not recognizable. In the ectosomal trabeculae between the subdermal chambers, the spicules have in general a radial or obliquely radial position and project. Such aggregations of spicules are however often too wide and not compact enough to be called tracts. The dermal membrane contains, in addition, abundant more or less tangential spicules. The oxea is the usual smooth, slightly curved form, tapering evenly to sharp points, 700–900 by 26–32 μ with smaller sizes. Now and then a style occurs.

The species, as generally conceived, is cosmopolitan, of no particular habitus, and without any very marked characteristics. The oxeas are always relatively long and slender; Ridley and Dendy (1887, p. 3) put the range in length at 200–1000 μ, Lundbeck (1902, p. 7) at 350–1000 μ. The spicules are especially large in the Indo-Pacific specimens (Topsent 1901, p. 10). The species has in recent years been recorded several times from this region by Dendy (1905, p. 146; 1916*b*, p. 112; 1921*b*, p. 37).

The spicules of the interior are characteristically strewn without order and thickly; those of the dermal membrane may be closely packed in all directions, some tangential, some radial and projecting, others oblique; but often the dermal spicules are so arranged as to form a rete with 3 to many sided meshes (Bowerbank, 1866, p. 229; Lundbeck, 1902, p. 17; Dendy, 1905, p. 146). Since the spicules are free to move, the difference in arrangement of the dermal spicules may possibly be correlated with the physiological state of the sponge. Sponges are included in the species, in which the spicules of the interior show a strong tendency to arrange themselves in coarse fibers and in which there is a well developed dermal reticulation of spicular fiber (Dendy 1916*b*, p. 113).

The simplicity of the skeleton makes it difficult to pick out what racial differences may exist in *Halichondria*, and perhaps *H. panicea*, as employed to-day, is a conglomerate, which will be analyzed as we learn more about the structural details of individuals in different parts of the world. This appears to be the attitude of Hentschel (1914, p. 135).

HALICHONDRIA VARIABILIS Lindgren.

Halichondria variabilis Lindgren, 1898, p. 285.

Lindgren's species (1898, p. 285) was based on sponges from Cochin China and Java. The basal part of the body sends up fingerlike processes; spicules of interior partly strewn irregularly, partly combined in tracts; ectosomal tracts, 3–4 spicules thick, support small, sharp dermal conuli, projecting beyond the apices of the latter. Surface of sponge everywhere "granulated" by the conuli. Oxea, 720 by 16 µ, gradually pointed.

Hentschel (1912, p. 408) refers to this species a specimen from the Aru Islands, agreeing in habitus as well as in the other features with Lindgren's types. The oxeas are slender, 520–1160 µ long.

The spicules and their arrangement in the interior would scarcely mark off this species from *H. panicea*, but the small sharp dermal conules, supported by more or less radial ectosomal spicular tracts, do. This I conceive to be the distinguishing mark of the species along with spicules of the same type as in *H. panicea*. The irregularity in the curvature of the oxea to which Lindgren calls attention, and which Hentschel found was common in the larger spicules of his specimen, is slight as Lindgren's figure (1898, pl. 19, fig. 1) shows. The habitus too is probably only a local feature.

To this species may be referred a specimen from station D5414. The sponge is a bar-shaped, somewhat flattened, mass, rising from an enlarged base; total height 150 mm., width 25 to 40 mm. Oscula 4–5 mm. in diameter with some smaller ones, numerous; chiefly along one of the narrow sides of the bar, extending thence on to the base and the upper extremity. Large canals of about the diameter of the oscula are present in the interior of the sponge. The surface shows conspicuous, tangential, subdermal canals, 1–2 mm. wide, each with some surrounding collenchyma. These canals are about 5 mm. apart and combine with one another, forming more or less of a connected reticulum. Such canals occur in specimens of *H. panicea*, and Dendy calls attention to them in *H. reticulata Baer* (1916*b*, p. 113). They are especially developed in the *Albatross* specimen.

The small sharp conules, characteristic of the species, are about 1 mm. apart. In addition, the surface exhibits a feature, to which attention has not been called, and which may not be constant. It is conspicuous when the sponge is examined with a lens. From each conulus radiate a number of narrow ridges, all combining to form a fine dermal reticulum, composed of ridges or of trabeculae which are not elevated, between which lie thinner areas of dermal membrane riddled with pores. The ridges and trabeculae are denser and more fibrous than the rest of the dermal membrane; they are not supported by a skeletal reticulum. This reticulum is essentially the same as that found in many horny sponges, where the varying appearance of the surface in the same specimen indicates that the reticulum, which is conspicuous when the pores are open, may disappear when the pores have been closed for a considerable time. It offers a striking case of analogical resemblance between widely distant sponges.

As in the already described specimens, the spicules of the interior are both scattered irregularly and combined in loose tracts. The ectosomal tracts which extend into and support the conules, slightly projecting beyond the apices of the latter, may be radial or quite oblique. Save for these, the dermal membrane is almost free of spicules; it contains only a few scattered ones. Perhaps this is a variable feature, for Lindgren (1898, p. 285) says: "In the dermal membrane the spicules are quite without order."

The oxeas are slightly curved, taper gradually to sharp points and commonly measure 650–770 by 24–30 μ. A slight irregularity of curvature is present in some of the spicules (would it not be found, on searching, in other species?). A more definite, doubtless local, peculiarity is a feeble annulation exhibited by some of the spicules, which may or may not be in the middle.

It may be noted that some of the north Atlantic *Halichondrias* have also differentiated ectosomal spicular tracts which support the dermal membrane on their projecting ends. This resemblance of these species (*H. oblonga* and *H. tenuiderma*, Lundbeck, 1902, pp. 24, 26) to the East Indian form is probably only analogical—namely, due to the independent occurrence and fixation of the same variation in organisms having a common basic constitution.

Genus RENIERA Nardo (1847).

Reniera NARDO, 1847.—O. SCHMIDT, 1870, p. 39.—RIDLEY and DENDY, 1887, p. 14.

Skeleton typically a close and uniform reticulum, each side of the polygonal mesh formed by a single spicule. Spongin usually at the nodes of the reticulum. The side of the mesh may however be multispicular, and long multispicular tracts may develop.

RENIERA IMPLEXA Schmidt, var. BAERI, new variety.

Reniera implexa SCHMIDT, 1868, p. 27.—BAER, 1906. p. 13, pl. 1, fig.8; pl. 4, figs. 15–17.

One specimen, from a tide pool, San Pascual, Burias Island

Sponge consists of a clump of about 30 tubes, which arise from a common amorphous basal portion, itself attached to a clump of slender stony phloeodictyine fistulae, perhaps belonging to *Phloeodictyon cagayanense* (oxeas of fistulae measure about 230 by 12 μ). The *Reniera* tubes exhibit a great deal of lateral fusion: this is so extensive in places that the individuality of the tubes is here marked externally only by the cloacal apertures. Tubes range from small ones 25 mm. high and 12 mm. in diameter to larger ones 50 mm. high and 25 mm. in diameter. Tube wall is thick, diameter of cloaca about one-third to one-fourth total diameter. Terminal cloacal apertures relatively large, up to about 8 mm. in diameter. Common amorphous basal part of sponge reaches 25 mm. in height; greatest width of whole specimen 100 mm., greatest height 75 mm. Sponge somewhat compressible and elastic, but soft and easily torn. Color now a light dirty brown.

Subdermal cavities of medium size underlie the thin dermal membrane. From these, narrow afferent canals extend radially into the wall. Corresponding radial efferent canals open by unobstructed apertures directly into the cloaca; apertures of these canals close together, 1½ mm. in diameter to a fraction of a millimeter. Outer surface of sponge, where it is well preserved, is minutely conulose: conuli a small fraction of a millimeter high, about one millimeter apart but spaced irregularly, vaguely shaped and feeble. Sponge, taken in March, full of embryos.

Skeleton essentially a renieroid reticulum, meshes square or triangular, the side unispicular and about length of a spicule; transparent spongin at nodes of reticulum: oxea of the cylindrical type, 132 by 6 μ. In addition, the tube wall includes some inconspicuous polyspicular tracts which pursue in general a longitudinal course; these tracts are loose, about 2–6 rows wide. Dermal reticulum unispicular; meshes triangular, square, rectangular, or polygonal, like those of the inner skeleton or often corresponding to two or three of the latter; a few free, tangential, spicules also present in the dermal membrane.

Holotype.—Cat. No. 21293, U.S.N.M.

The *Albatross* sponge is evidently the same form as that described by Baer (1906), from the neighborhood of Cape Town. Baer's excellent photograph (pl. 1, fig. 8), although of a sponge somewhat smaller than mine, shows the habitus. The oxeas are of about the same size as in the *Albatross* sponge. Baer finds that the dermal membrane is perforated by uniformly distributed afferent apertures 1 mm. wide. Perhaps in his specimens the actual dermal membrane had been torn off, thus leaving uncovered the apertures of the radial afferent canals. Baer refers his sponge to *R. implexa*, but now that another specimen has been taken from a different locality in the east, the form may well be set apart from the type.

The type was based (Schmidt, 1868, p. 27) on Adriatic specimens. It was then recorded by Ridley and Dendy (1887, p. 15, pl. 1, fig. 4) and by Topsent (1904, p. 244) from the Azores, by Dendy (1905, p. 142) from Ceylon, and by Row (1911, p. 315) from the Red Sea. The North Atlantic and Mediterranean sponges of the species have a characteristic habitus (Ridley and Dendy, 1887, Topsent, 1904). The sponge tubes are elongated, slender (about 7–10 mm. wide in the *Challenger* specimen figured), and stipitate. Longitudinal polyspicular tracts probably always occur in addition to the renieroid reticulum. In Mediterranean specimens examined by Ridley and Dendy the oxeas measured 138 by 7 μ, in the North Atlantic specimens the recorded range is from 160 by 6 μ (Ridley and Dendy) to 200 by 7–8 μ (Topsent). In Dendy's specimens from Ceylon the tubes are only about 5 mm. in diameter, the multispicular fibers loose, feeble, and sparsely present; oxeas 136 μ by 4 μ. Row's Red Sea sponges resembled the Mediterranean forms.

Genus PETROSIA Vosmaer (1887).

Petrosia (*Schmidtia* Balsamo Crevelli) VOSMAER, 1887, p. 338.

Petrosia RIDLEY and DENDY, 1887, p. 9.—TOPSENT, 1894c, p. 4.—LUNDBECK, 1902, p. 54.—HENTSCHEL, 1912, p. 389 (some discussion of variation).

Renierinae in which the skeleton consists of a reticulum of stout polyspicular fibers or looser tracts, with very little or no spongin, and often of scattered spicules besides. Spicules, oxeas or strongyles, sometimes with intermediates. Consistency very hard, almost stony. Some species approaching *Pachychalina.*

PETROSIA TESTUDINARIA (Lamarck).

Plate 40, fig. 6.

Alcyonium testudinarium LAMARCK, 1815, p. 167.

Reniera testudinaria RIDLEY, 1884, p. 409.

Petrosia testudinaria (Lamarck) DENDY, 1889, p. 77.

Dendy, 1889 (p. 77), gives a detailed account of this species, based on the study of a specimen from the Gulf of Manaar. This cup-shaped sponge was 400 mm. high, 300 mm. wide at the base; cavity 180 mm. deep, its aperture 380 by 170 mm. Outer surface with prominent parallel ridges running vertically, ridges 40–50 mm. high and about 50 mm. apart. Texture of dry sponge, fragile and crumbling. Wide canals, at right angles to general surface, terminate on margins of ridges, there covered in by networks. Similar, covered, oscula occur in the wall of the cavity. Spicular network covering in the oscula similar to that which covers the general surface of the sponge, but coarser. Skeleton a coarse irregular network of stout fibers composed of a great number of spicules loosely and irregularly bound together. Spicules slightly curved, ranging from oxeate to strongylate, varying much in size especially in diameter, typical full-grown spicules 370 by 17.5 μ.

Ridley had earlier (1884, p. 409) studied two specimens of this species (*Alcyonium testudinarium*, Lamarck, 1815) from Queensland. He gives the dimensions of one, 6 inches high by 6 inches broad. Both specimens were crateriform and with ridges on the outer surface. Spicules, strongyles simply rounded at ends, sometimes tapering somewhat to the ends, along with some oxeas; average maximum size 320 by 16 μ. Ridley says his specimens agree with Lamarck's type.

Dendy (1905, p. 144) briefly describes and figures another specimen from the Gulf of Manaar. It is wider than high, about 170 mm. wide, 120 mm. high, and with the meridional ridges (ribs). Hentschel (1912, p. 403) records a small specimen, 80 mm. high, from the Aru Islands; spicules 358–470 μ long. Topsent (1920*d*, p. 8) describes specimens from Singapore; the spicules are oxeas reaching 415 by 26 μ.

The vertical ridges on the outer surface of the sponge appear to be a characteristic of the species, but Dendy would include forms in which they are replaced by very irregular outgrowths (Dendy, 1889, pl. 3, fig. 2, showing a specimen from the Mergui archipelago), and Hentschel in his definition of the species would also include such forms. I suggest that they may be referable to another species, *P. lignosa* (see below).

The *Albatross* collection includes a fine dried specimen from station D5147 (pl. 40, fig. 6), agreeing well with Dendy's description. (See previously.) The vase is wider than high, 300 by 270 mm., the crateriform cavity 130 mm. deep. The meridional ridges are about 20–30 mm. apart, some of them near the base of the sponge breaking up into irregular projections. Sponge is firm, but not nearly so heavy nor so woody as the *P. lignosa* of this report. Color, light brown to light gray on the surface, darker inside.

The canals terminating (beginning probably) on the margins of he ridges and those leading into the cavity of the cup are as Dendy describes.

I may add the following notes on the skeleton. The internal skeletal reticulum is in general coarse and irregular, with some scattered spicules. But owing to the anastomosis of fibers in one and the same plane, reticular lamellae about 0.2 mm. thick are differentiated. These lie about 1 mm. apart, roughly parallel to one another and to the two surfaces of the vase. The meshes of the lamellae are small and the texture is fine; characteristic meshes measure 80, 60, 40 μ in width. Between the lamellae the framework is coarser; the fibers often 140–175 μ thick, characteristic meshes measuring 1.0, 0.7, 0.5, 0.4 mm. in width.

The skeleton of the ectosomal region is finer and more regular than that of the interior, showing radial fibers and transverse connectives. There are some minor differences between the dermal skeleton of the exterior and that of the cloacal wall. Thus the meshes of the skeletal reticulum covering the outer surface are commonly 175–350 μ wide, while those of the reticulum lining the cavity measure about 175–260 μ in width. There are more projecting tips of radial fibers on the inner than on the outer surface (due to wearing?). The strands of the reticulum on both surfaces are mostly 3–5 spicules wide. There is for the most part one pore in each mesh of the reticulum.

The characteristic spicule is an intermediate, 385–400 by 20 μ, smooth, slightly curved, ends tapering but rounded off instead of pointed. Strongyles of same size, with ends evenly rounded off, also occur. Sharp-pointed oxeas occur among the spicules of smaller sizes.

PETROSIA TESTUDINARIA, var. FISTULOPHORA, new variety.

Plate 40, fig. 5; plate 41, figs. 1, 2; plate 48, fig. 8.

Three dried specimens from stations D5249, D5253, D5254, and alcoholic fragments from D5253 and D5254 constitute the material on which this variety is based. The essential difference from the type lies in the fact that the outer surface bears fistular processes instead of vertical ridges, but there are intergrading individuals.

The sponge from station D5254 (pl. 41, fig. 1) represents the extreme amount of divergence from the type. It is an oblate spheroidal mass about 300 mm. wide and 160 mm. high. It was attached by the whole under surface, which is somewhat convex and rough. The crateriform cavity, opening on the upper surface, is small, only 100 mm. wide and 60 mm. deep. Sponge is light brown, darker inside; firm, but in the dried state easily broken; considering its bulk, not heavy.

The outer surface bears very numerous radiating hollow projections, which may be designated as fistular processes. These are 15 mm. or less apart, somewhat flattened in the meridional plane and closed at the outer end by dermal membrane. A typical process measures 15 mm. in height, with cross diameters of 20 and 12 mm., the long cross diameter lying in a meridional plane of the sponge; wall of the process about 3 mm. thick. The cavity in each fistular process is a large afferent canal, which has the flattened shape of the process and extends deep into the sponge body, branching as it goes. The surface of the crateriform cavity is folded so as to give rise to maeandriform ridges about 5 mm. high and 2–3 mm. wide. Numerous and relatively large efferent canals, 5–6 mm. in diameter, lead into the crateriform cavity; their apertures covered by the dermal membrane of this cavity; the canals radiating as cylindrical tubes deep into the sponge body.

The skeletal framework includes reticular lamellae like those of the type (see previously), but coarser, the meshes measuring 175–350 μ in width; spiculo-fibers composing the lamellae about 150–175 μ thick along with thinner and looser spicule tracts. The lamellae are 1–2 mm. apart, in the superficial regions roughly parallel to the outer and inner surfaces of the sponge; in the interior they are, sometimes at least, arranged concentrically to the larger canals. The skeleton between the lamellae may be the usual coarse, irregular one, but in places there is found a system of straight pillar-like spiculo-fibers, about 150–200 μ thick and 0.5 to 2 mm. apart, which run from lamella to lamella, vertically to them; between the pillar-like fibers there is only a very scanty, irregular, reticulum.

The dermal skeletal reticulum of the outer surface is made up primarily of spiculo-fibers about 175 μ thick, between which stretch thinner looser spicule tracts, composed often of only two or three spicules; meshes 175–350 μ wide. Skeletal reticulum of the inner surface about the same, perhaps slightly coarser (in the *Albatross* specimen of the type, see above, it is somewhat finer. The relation is probably a point of individual variation).

The spicules (pl. 48, fig. 8, *a*) are sharp-pointed oxeas, 400–440 by 22 μ. They are thus somewhat larger, and differ in respect to the apices from the specimen of the type, described above. But the precise shape of the apex, as the other specimens of the variety show, is a matter of individual variation.

The specimen from station D5253 (pl. 40, fig. 5) represents about a fourth of a larger but similar sponge. In this sponge the diameter was about 400 mm., height 200 mm.; the crateriform cavity, as in the other specimens of the variety, relatively very small. The fistular processes and included canals are larger, especially in that cross diameter which represents a meridional plane of the sponge. The spicules (pl. 48, fig. 8*b*) agree with those of the first specimen, except that they are rounded at the apices, thus not differing from the characteristic spicule in the *Albatross* specimen of the type.

The specimen from station D5249 (pl. 41, fig. 2) is complete. It is the smallest of the three, the horizontal diameter being about 200 mm., the height 140 mm. The cavity is 90 mm. wide and 60 mm. deep. The sponge is intermediate in habitus between the type and the variety. The fistular processes are either represented by meridional ribs or are very flattened and arranged in meridional rows. The spicules measure 400 by 20 µ, and are, as in the preceding, round-pointed oxeas—that is, rounded off at the apex. Sharp-pointed smaller sizes of the spicule occur.

Holotype.—Cat. 21285, U.S.N.M.

The *Albatross* specimens of type and variety make a series that is very suggestive for the study of the origin and nature of variations. But how far the differences are phaenotypic and how far due to racial differences remains to be ascertained.

The laminated condition of the skeleton which I have described is something not peculiar to *P. testudinaria*, for Hentschel has described in two other forms, *P. truncata aruensis* and *P. nigricans irregularis* (1912, pp. 402, 405), a concentric arrangement which is somewhat similar. Perhaps such lamellae are to be looked on, in part, as Hentschel suggests, as representing growth rings, but it would seem that they constitute, at least in *P. testudinaria*, an established, constant feature of the skeletal arrangement.

The laminated structure of the skeleton in these species of *Petrosia* and in *Coelosphaera toxifera* of this report probably only constitutes a case of analogical resemblance. Petrosia is probably however a near relative of the *Phloeodictyinae* (see Lundbeck, 1902, p. 56; 1910 p. 28), and a form like *Petrosia testudinaria*, var. *fistulophora* constitutes, at least in the matter of morphological plan, an intermediate, showing how a vase-shaped *Petrosia* through continued increase in thickness of wall and decrease in size of the cavity, coupled with the localized outgrowth of surface projections, might pass into a massive, fistulate, phloeodictyine sponge.

PETROSIA LIGNOSA, new species.

Plate 41, fig. 3; plate 48, fig. 9.

Two dried specimens from stations D5147 and D5250. The specimen from D5147 (pl. 41, fig. 3) represents about one-third of a great conical vase with small truncated solid base (vase was sawn in two when collected). Total height of vase about 600 mm.; diameter of mouth of vase about the same; wall in general 50–75 mm. thick. The sponge from D5250 is a vase 400 mm. high; cross diameters of mouth 300 mm. and 500 mm.; thickness of wall 110 to 150 mm. In both, the outer surface is closely beset with large, gnarled protuberances disposed without any definite arrangement. Between many of these and also on them are abundant, small, mammillate (subconical or subcylindrical) projections, rounded apically, 5 to 15 mm. high with a width something less than the height. Inner surface of vase smooth. Canals, up to 5–6 mm. in diameter, extend in radially from both surfaces, their mouths covered over by dermal skeletal reticula.

The skeletal framework includes main fibers, about 225 μ thick, which ascend in the body wall, arching so as to radiate obliquely toward both outer and inner surface. Somewhat thinner connectives extend transversely between these, giving rise to a regular network with rectangular meshes, commonly about 1 mm. wide. In a longitudinal section of the sponge, the main fibers and connectives present a very ladder-like appearance. The fibers are independent, not associated together as parts of a reticular lamella, as in *P. testudinaria.* They consist of closely packed megascleres with a little spongin.

There is a dermal skeletal reticulum on both surfaces. Meshes in the neighborhood of 300 μ wide, commonly 4 or 5 sided, with the side formed by a tract of a few spicules or sometimes by a single spicule. The tips of the radial skeletal fibers project: and at least where the surface is well preserved, there are closely set small, radial bundles or tufts, 60–120 μ high, composed of the very small megascleres, which project from the tangential tracts of the dermal skeleton.

The megascleres range from very large ones through all sizes to very small ones. The total range observed was 420 by 20 μ to 32 by 6 μ. As in the other species with this skeletal peculiarity, the spicules fall more or less in two classes, large ones and very small ones. The common size for the large spicules is, in one specimen, about 300 by 16 μ, in the other 300 by 20 μ. For the small spicules the common size is about 40 by 6 μ to 80 by 10 μ. The spicules (pl. 48, fig. 9) are smooth, slightly curved, and range from oxea to strongyle: occasionally even a style (fig. 9, *d*) is formed. There are some differences between the individual sponges as to the prevailing shape of the spicules. Thus in the specimen from D5250 pointed oxeas are absent or nearly so, the characteristic megasclere being a strongyle in which the ends taper very slightly or not at all (fig. 9 *a*). In the other specimen the characteristic large spicule is an intermediate (fig. 9, *b*), with tapering ends which are not sharp but rounded at the apex. But sharp-pointed oxeas (fig. 9 *c*, *e*) also occur in abundance. The very small spicules (fig. 9, *f*) are in both specimens strongyles or intermediates. They occur everywhere along with the large spicules, but are especially abundant at the dermal surface, in the projecting ends of the radial skeletal fibers and forming the small radial tufts referred to above.

Holotype.—Cat. No. 21283, U.S.N.M.

PETROSIA LIGNOSA, var. PLANA, new variety.

Plate 41, figs. 4, 5.

Two dried vasiform sponges from Togian Bay, Togian Island, Gulf of Tomini, Celebes, clearly belong to the above species but differ conspicuously from the type in that the outer surface is smooth or only vaguely roughened, lacking the gnarled protuberances. Both specimens are roughly cylindrical, 300–340 mm. high, 95–130 mm. wide, diminishing somewhat above, the wall, 25–50 mm. thick, thinning away to an edge at the mouth of the vase. One of them expands below into a large solid base and the indication is (pl. 41, fig. 5) that a second vase arose from the base but was sawn off. The sponges are of the same heavy, woody character as the type; the color is the same, and the canals are essentially similar.

The fibers of the skeletal framework are like those of the type but somewhat thicker, ranging up to 350–400 μ in thickness. The framework is somewhat coarser than in the type, the meshes often 1 to 1.5 mm. wide. In neither specimen is the framework as regular as in the type, although in the superficial region everywhere fibers radial to the surface and connectives are distinguishable. The individual differences have some interest and may be noted. Thus in one of the two sponges (pl. 41, fig. 4), conspicuous long main fibers, such as are present in the type, were not observed, the skeleton consisting simply of a coarse irregular reticulum, with radial fibers and connectives differentiated at both surfaces. In the other specimen (pl. 41, fig. 5) the base in its outer part shows radial fibers with transverse connectives, giving large squarish meshes; internally the skeleton of the base is irregular. In the wall of the vase long ascending main fibers are present but their distribution is peculiar and different from that of the type. Instead of arching over toward both surfaces, they ascend just beneath the dermal membrane of the sponge cavity, and arch over to the outer surface, thus passing completely through the wall of the vase.

The dermal skeleton is as in the type, the meshes about 225 μ wide. The coarser fibers of the superficial internal skeleton show through the surface reticulum, and thus may seem at first sight to divide it into a system of areas, each of which appears subdivided by the strands of the dermal reticulum proper.

The spicules are similar to those of the type and are distributed in the same way, the very small ones forming small radially projecting tufts, closely set on the dermal reticulum. They do not reach as large a size as in the type, the large spicules measuring in one specimen (fig. 4) 240–280 μ by 14–16 μ, in the other (fig. 5) 240–280 by 13–14 μ. They range down to very small ones of about the same size as in the type. There are individual differences between the two sponges as to the shape of the spicule ends. In one specimen (fig. 4) the spicules, large and small, are almost all oxeas with sharp points. In the other (fig. 5) the prevailing type, both for large and small spicules, is the intermediate (oxea rounded at the apices); but typical strongyles are common and there are some sharp-pointed oxeas.

Holotype.—Cat. No. 21337, U.S.N.M.

This species adds one more to the list of Petrosias in which the spicules range from large to very small ones. Besides the Mediterranean *P. dura* (O. Schmidt) and the North Atlantic *P. crassa* (Carter), which is sometimes large and with crateriform cavity (Topsent, 1904, p. 241), *P. strongylata* Thiele (1903, p. 938) from Ternate, *P. truncata*, var. *aruensis* Hentschel (1912, p. 402) from the Aru Islands, *P. nigricans* Lindgren (1898, p. 287) from Java, and *P. nigricans*, var. *irregularis* Hentschel (1912, p. 405) from the Aru Islands, may be noted.

The differences offered in the skeletal framework by the three specimens of this species (type and variety) have some interest. They are, in all probability, individually acquired, not hereditary, differences. Assuming this, it becomes worth while to formulate the question whether some of the individual peculiarities are not adaptive responses (of growth and differentiation) to mechanical stresses and strains, such as those exerted by water currents and the weight of the whole body—as, for instance, in the case of bones, where there seems to be a very considerable power of adapting the arrangement of bone lamellae to the mechanical needs of the individual case? Experimentation on this point is doubtless feasible.

PETROSIA SIMILIS Ridley and Dendy, var. GRANULOSA, new variety.

Plate 41, fig. 7.

Petrosia similis **Ridley and Dendy, 1887, p. 9.**

Several elongated, subcylindrical, more or less flattened pieces from Station D5141. Three measure, each, about 100 mm. long; the fourth is shorter; transverse diameters in typical regions, 20 and 17 mm., 30 and 20 mm., 35 and 25 mm. The pieces widen terminally, where one is slightly lobate. Sponge heavy, firm and incompressible, but not stony; dark reddish brown, owing to the presence throughout the body of quantities of cells containing reddish brown granules.

Surface appears smooth to the eye; uniformly dense or showing the ends of very small canals, a fraction of a millimeter in diameter, distributed generally about 2 mm. apart. With a lens the surface, where uninjured, is seen to be distinctly, though minutely, conulose, radial skeletal fibers entering into and supporting the conuli. Pores closed. Oscula abundant, mostly about 3 mm. in diameter. They exhibit an imperfectly developed bilateral distribution, in that, although scattered ones occur, they tend to be confined to the opposite and narrower sides of the sponge, thus forming somewhat vaguely marked rows. Interior of sponge compact, canals small; ratio of soft tissue to skeleton fairly high.

Skeletal framework a reticulum of spiculo-fiber with a good many scattered spicules. Fibers fairly compact, frequently 80–120 μ thick, although thicker and slenderer ones occur; spicules cemented together by a small amount of spongin. Main fibers may be distinguished, although they are not conspicuously differentiated, which in the axial part of the sponge pursue a longitudinal course. These curve outward in the peripheral part of body, extending radially toward the surface, where they enter and support the little conuli. Meshes of skeletal reticulum 200–700 μ wide.

The dermal membrane includes, besides the projecting ends of the radial fibers, tangential spicules. These in places are scantily scattered, not forming a reticulum, but in other places are groupeo in slender tracts, one to a few spicules thick, which form a reticulum with meshes somewhat less in width than the length of a spicule.

Oxeas, of the usual type, cylindrical—namely, beginning to taper near the ends; slightly curved; 220–260 by 14 μ.

Holotype.—Cat. No. 21279, U.S.N.M.

The *Albatross* sponges are close to the type (Ridley and Dendy, 1887, p. 9), in elongated specimens of which the oscula tend to become arranged in a row. Distinguishing marks of the variety are the conulose surface, the partial development of a special dermal skeleton, the presence of so many granular cells, and the color. In the type the dermal membrane is supported by the projecting ends of the radial fibers, but lacks other special dermal skeleton; conuli are not recorded. The type is recorded from south of Cape of Good Hope, Kerguelen, between Kerguelen and Heard Island (Ridley and Dendy, 1887); Ceylon waters (Dendy, 1905, p. 145); Aru Islands (Hentschel, 1912, p. 406). Varieties have been recorded from between Strait of Magellan and the Falkland Islands (Ridley and Dendy, 1887); Amboina (Topsent, 1897, p. 476); Ceylon waters (Dendy, 1905); Aru Islands (Hentschel, 1912); off Galapagos Islands (Wilson, 1904, p. 121). Of the varieties, *compacta* is recorded for the Philippines by Ridley and Dendy and by Hentschel. This variety differs from the type and from the *Albatross* specimens in being stony hard and in the absence of tufts of spicules (ends of radial fibers) supporting the dermal membrane.

Hentschel (1912), is inclined to regard the species as an artificial congeries of forms, and it must be owned that the whole group, type plus varieties, is rather vaguely delimited.

In several *Petrosia* specimens the surface is described as "rough" or "granular." Perhaps a closer examination will show that in some of these the surface is minutely conulose, as in the variety here described.

PETROSIA CRUSTATA, new species.

Plate 41, fig. 6; plate 49, fig. 2.

Station D5414, one specimen. Sponge an amorphous mass, thin and incrusting below, that has grown round and is penetrated by a Gorgonia-like alcyonarian. Greatest diameter 60 mm. The sponge is surmounted by a *Discodermia emarginata* (the compact mass at the summit in pl. 41, fig. 6), and is infested with small barnacles, round each of which the sponge tissue forms an elevation open at the summit; the apertures, scattered over the surface, look at first sight like oscula.

Surface of sponge white, smooth, aporous (to eye and lens), and stony. Interior whitish with a tinge of yellow, firm but far from stony, friable; permeated by numerous canals visible to the eye, these varying in diameter from minute ones up to canals 2 mm. wide, but comparatively few are over 1 mm. wide; many canals conspicuously surrounded by collenchyma. The pores are closed, but gaps in the layer of dermal spicules indicate that they everywhere perforate the dermal membrane. Oscula few, scattered, about 3 mm. in diameter; raised slightly above the surface on short oscular tubes which are scarcely more than rims, 1–3 mm. high. The osculum leads into a canal of corresponding width, which not far from the surface receives several efferent canals.

There is a very irregular skeletal reticulum of compact spiculo fiber, with abundant free spicules scattered between the fibers. Spicules of the fibers packed closely and cemented together with a small amount of spongin. Fibers of the reticulum 50–200 μ thick; meshes have about the same range in width. This reticulum extends to the surface of the sponge, and to the lining walls of the largest canals, in which the abundant tangential spicules form a lining reticulum of spiculo-fiber with rounded meshes. All but the larger canals are, however, surrounded by tissue, collenchymatous in some cases, which lacks the skeletal reticulum and contains only scattered spicules. Since there are numerous canals, many of considerable size, numerous gaps in the skeletal reticulum are produced, occupied either by canals or by canals surrounded by sponge tissue lacking the reticulum. Such interruptions may be thought of simply as larger meshes in the reticulum as a whole; they are of all sizes up to the diameter of the large canals. These many interruptions of different sizes give to the skeleton the appearance of a very heterogeneous structure.

In the tissue surrounding the canals of considerable size, which, as said above, does not contain any part of the skeletal reticulum but only scattered spicules, it may be seen in thick sections that the spicules cross one another in all directions producing in places, when seen with a low objective, the effect of a vague, loose reticulum; but there is in such places no union between the spicules and no regularity of arrangement.

The arrangement of the fibers and meshes of the skeletal reticulum is quite irregular, although of course there are some fibers in the immediate neighborhood of the surface more or less radial to it, and the same is true of the walls of the largest canals.

The dermal membrane contains a thin crust-like layer, one to a few spicules thick, of tangential spicules, with some obliquely radial ones; this layer shading off into the skeletal reticulum. In it the spicules cross in all directions. While the skeletal reticulum reaches and supports the dermal membrane, and some of the fibers are radial to it, there are no fibers projecting from it.

The spicules (pl. 49, fig. 2) are smooth, cylindrical, slightly curved oxeas, 130–160 µ by 8–10 µ; rather abruptly pointed, inclining toward the tornote shape. A variant occurs having the shape of the strongyle; those seen were shorter than the characteristic spicule.

Holotype.—Cat. No. 21281, U.S.N.M.

The hard, smooth dermal layer, constituting a thin crust, and the variable texture of the internal skeleton caused by the presence of so many areas of all sizes into which the skeletal reticulum does not penetrate, are the most salient characteristics of this species.

Genus TRACHYOPSIS Dendy.

Trachyopsis DENDY, 1905, p. 147.

Renierinae in which the main skeleton is composed of a dense, irregular network of oxeas, while the surface is protected by similar spicules arranged in vertical brushes, which support the pore-bearing dermal membrane.

TRACHYOPSIS HALICHONDRIOIDES Dendy.

Trachyopsis halichondrioides DENDY, 1905, p. 147.

A specimen of this species from station D5218 is massive and elongated, about 60 by 30 mm. There are no indications of attachment, and the sponge may have been a "roller." The oscula are not obvious; doubtless closed. There is only a single elevation corresponding to the tubular oscular processes described by Dendy (1905, p. 147); this includes a canal, 2 mm. in diameter, extending inward from the apex of the elevation.

The very smooth surface and compact texture; the halichrondrioid arrangement of the skeleton, with vague tracts radial to the surface terminating in brushes of projecting oxeas; the shape of the oxea;

the color; all these are points of resemblance, which make it necessary to include the sponge in Dendy's species, which is based on a specimen from Ceylon waters.

There are, of course, minor quantitative differences from the type. The spicules, disregarding the smaller sizes, range from 400 by 12 μ to 520 by 20 μ; upper limit in the type is 640 by 32 μ. In the type the oxeas of the dermal brushes project very slightly, and the brushes themselves are said to be dense. In the *Albatross* specimen the spicules commonly project 70–140 μ. The brushes are closely set, although, as is best seen in surface preparations of the dermal membrane, there are intervals between them. The brushes themselves are, however, not dense, but rather loose bouquets of spicules, varying down to little groups of two or three and indeed to single spicules. The dermal membrane also includes abundant oxeas scattered tangentially in all directions.

Dendy thinks the spicules of the dermal brushes are perhaps more slender than the spicules in general. This does not seem, from the measurements I have made, to be the case in the *Albatross* specimen.

The species has also been taken in the Red Sea (Row, 1911, p. 321). In these specimens the spicules reached a length of 600 μ. The *Albatross* specimen is in size intermediate between the type and the largest of Row's specimens, which measured 100 by 55 mm.

Subfamily CHALININAE.

Chalineae O. SCHMIDT, 1868.
Chalininae RIDLEY and DENDY, 1887.

Skeleton typically and almost always a network of horny spiculofibers, characterized by considerable regularity of arrangement; the spongin usually completely enveloping the spicules, which may be present in numerous rows or in a few or only one axial row; or the fiber may contain only a few scattered spicules. In extreme cases the spicules are vestigial or even completely absent, such forms becoming *pseudoceratose* (Dendy, 1905). The group extends over toward *Reniera* in that it includes species in which the skeleton is a combination of a renierine reticulum and distinctly chalinine fibers.

The group, which dates back to Schmidt, 1868, is taken in the sense of Ridley and Dendy (1887), Dendy, 1890, and Dendy, 1905. Topsent, 1894*c*, and Thiele, 1903, include *Toxochalina*, assignable because of its microscleres to the Gelliinae. Lundbeck, 1902 (p. 56), includes some of the phloeodictyine species: *Rhizochalina oleracea* and *carotta* Schmidt. Some of the forms, species of *Chalinopsilla* for example, included in Lendenfeld's (1889) Eusponginae are probably to be referred here.

Dendy, 1905 (p. 147), thinks the group is perhaps polyphyletic, including sponges derived from several genera of Gelliinae and Renierinae through strong development of spongin accompanied in some cases by loss of microscleres.

Genus PACHYCHALINA O. Schmidt (1868).

Pachychalina O. SCHMIDT, 1868, p. 8.—RIDLEY and DENDY, 1887, p. 19.

Not tubular. Surface smooth or spinose. Skeleton composed of stout fibers containing numerous spicules arranged in several rows.

PACHYCHALINA FIBROSA Ridley and Dendy.

Pachychalina fibrosa RIDLEY and DENDY, 1887, p. 19.

Station D5136, two specimens possibly representing pieces of an elongated sponge which had broken off from the general body and had healed, for the surface is everywhere covered with dermal membrane and spines. Station D5141, an elongated branching specimen. These specimens are well represented by the two figures of the species given by Ridley and Dendy (1887, p. 21, pl. 4, figs. 3, 4) and even in size are close to the sponges there portrayed. The general shape of the body, size and spacing of the spines, large size of the oscular depressions showing on the bottom the mouths of the efferent canals, appearance of the skeletal reticulum through the dermal membrane, all constitute points of resemblance between the *Challenger* and *Albatross* sponges.

The fibers of the main skeleton are 70–175 μ thick, with slenderer ones, and are completely filled with spicules. Abundant spicules are scattered between the fibers.

In the dermal reticulum, the fibers are 8–22 μ thick, some unispicular, more polyspicular (2–3–4 rows), with abundant spongin; meshes rounded and about as wide as the length of a spicule or less. This is evidently the finer reticulation described by Ridley and Dendy. Below and distinct from it are the superficial tangential fibers of the main skeleton. Such is, I take it, the typical arrangement, although quite often the coarser fibers do not lie beneath but form an actual part of the dermal reticulum. They evidently constitute the "coarser reticulation" of Ridley and Dendy.

The spicules are oxeas of the more cylindrical type, ends sometimes rounded; 88–96 by 3–4 μ.

Ridley and Dendy's types were from the Atlantic, off Bahia and Bermuda; a specimen from the Philippines was referred by them (1887, p. 22) to an unnamed variety of the species. Lindgren, 1898 (p. 293), identified as this species specimens from Java and Cochin China, and by merging certain species added to the distribution localities Christmas Island and the Mergui Archipelago. Hentschel, 1912 (p. 400), records the species from the Aru Islands but remarks that it is not sharply delimited from *P. diffusa* (Ridley). Hentschel adds (p. 402) that any division of the intricately varying *Pachychalina* forms into species and varieties has but little permanent value, a conclusion for which much may be said to-day as in O. Schmidt's time.

PACHYCHALINA FIBROSA, var. GRACILIS, new variety.

Station D5136, two masses perhaps originally united, each composed of several long, slender, subcylindrical, branching shoots, some of which reach 300 mm. in length. Similar specimens were taken at D5145. The shoots fuse with one another in an irregular, accidental fashion. Surface covered with large and prominent spines. Diameter exclusive of spines commonly about 6 mm.; but the shoot may be distinctly flattened, diameters in a typical case 7 mm. and 4.5 mm. Spines variable in size, 2–5 mm. high, mostly 2–5 mm. apart. Oscula 2 mm. or somewhat less in diameter, in a single row along a shoot, usually 5–6 mm. apart. A reticulum of yellow fibers shows plainly through the dermal membrane; nodes of the reticulum distinct, meshes 3–5 sided and about 1 mm. wide. Sponge light brown; firm, flexible, but easily cracked in bending.

Main skeleton a reticulum of stout fibers consisting of spongin cored by multiserially arranged megascleres. The reticulum has considerable regularity in that radial fibers and connectives are distinguishable, the latter commonly transverse and the meshes more or less rectangular.

Radial fibers 120–175 μ thick, core of spicules one-third to one-fourth total thickness of fiber. Connectives very similar but in general slightly slenderer and with a somewhat thinner core of spicules in which the individual spicules are less densely packed. Meshes of the reticulum 500–900 μ wide.

Spicules between the fibers of main skeleton not scattered as in *P. fibrosa* but surrounded and united by spongin, thus forming fine secondary reticula which occupy the meshes of the main skeleton. Fibers of the secondary reticula only about 8–20 μ thick, unispicular or containing 2–3 rows of spicules, spongin relatively abundant; width of mesh commonly near the length of a spicule but also greater.

Dermal skeleton essentially a fine reticulum of very slender mostly unispicular fibers relatively rich in spongin; width of meshes, which are rounded, about the length of a spicule or less. This fine reticulum as a rule overlies and is distinct from the superficial (tangential) fibers of the main skeleton which show beneath it and at first sight appear to divide it into a system of large meshes. And indeed some of these thick fibers do lie strictly in the dermal skeleton, the fine dermal reticulum on both sides of such a fiber not extending over it but meeting and uniting with it.

The spicules are strongyles, very slightly curved, 70–80 by 3–4 μ.

Holotype.—Cat. No. 21276, U.S.N.M.

This variety is well represented by Hentschel's figure (1912, pl. 15, fig. 7) of *Pachychalina diffusa* (Ridley), var. *affinis* from the Aru Islands, but the main fibers in Hentschel's sponge are poor in spongin and the spicules (tornotes) measure 80–112 by 5–7 μ. In the type of this species, *P. diffusa*, the fibers have more spongin, but the spicules are about as thick as in Hentschel's variety. (See Ridley and Dendy 1887, p. 22.) In ranging the *Albatross* sponge under *P. fibrosa* rather than *P. diffusa*, I have laid the greater weight on the size of the spicules and the less on the amount of spongin in the fiber.

Genus SIPHONOCHALINA O. Schmidt (1868).

Siphonochalina O. SCHMIDT, 1868, p. 7.—RIDLEY and DENDY, 1887, p. 29.

Tubular Chalininae in which the outer surface of the tube is smooth or comparatively so—that is, without the spinous processes of Spinosella.

SIPHONOCHALINA FASCIGERA Hentschel.

Plate 42, fig. 2.

Siphonochalina fascigera HENTSCHEL, 1921, p. 398.

Three dried specimens, one not labeled, the others from Tomahu Island (south of Boeroe or Bouro Island); large pieces of seven tubes, in alcohol, from Tomahu Island; two alcoholic specimens from Station D5136.

The finest specimen, dried, from Tomahu, consists of about 10 tubes arising from a common base. The tubes are larger and with thicker walls than in Hentschel's specimens (from the Kei Islands). The height of the tubes is 300–360 mm., diameter about 25 mm., wall about 3 mm. thick, thinning away to an edge round the large terminal aperture. Surface varies from smooth to conulose, the upper part of the tube smoother than the lower. The other dried specimens consist, each, of a few tubes united below; in these the outer surface is smooth.

The Tomahu Island alcoholic specimens, diameter of which reaches 30 mm., wall 2–3 mm. thick, show one case of branching, several cases of ordinary lateral fusion between tubes, and some interesting tendril-like structures. These are solid slender outgrowths, 1–2 mm. thick, reaching 30 mm. in length, which on two tubes have developed in large number especially round the cloacal edge but also from the neighboring lateral wall. Most of them taper from the base to the apex, which is free. But some extend from tube to tube, fastening the tubes together; in these the connection with each tube is expanded, the middle part slender. These tendril-like structures, it would seem from the anatomy, provide the sponge tubes with a specialized means of gaining support, in that they can establish connection between tubes which are some distance apart.

Abundant small canals extend in radially from both inner and outer surfaces of the sponge. The apertures on the inner surface, oscula, are about 0.5 mm. or less in diameter; not covered in by reticular membranes. On the outer surface, the canals (afferent) are covered in by the dermal reticulum.

The slender longitudinal fibers, 20–30 μ thick, are as Hentschel states, typically unispicular, although such fibers occur containing in places two or even three rows of spicules. The slender fibers combine to form bundles as in Hentschel's specimens; this feature is variable and is less marked in the specimens from station D5136 than in the others. The meshes of the unispicular renieroid network extending between the longitudinal fibers are 3, 4, or 5 sided, with spongin showing at the angles. The dermal reticulum is only the most superficial part of the general skeletal network. The oxeas measure commonly 80 by 4 μ, reaching 90 by 5 μ, and are therefore somewhat larger than in the type specimens.

Hentschel (1921) has called attention to the unique character of the skeleton in this form, and to the resemblance offered to certain species of Reniera. The long fibers are, however, of a distinctly chalinine type, and the habitus is that of *Siphonochalina.*

SIPHONOCHALINA CRASSIFIBRA Dendy.

Siphonochalina crassifibra Dendy, 1889, p. 82.

Several specimens, along shore, Tataan, Tawi-Tawi.

One specimen is a single tube as if independent, attenuated at extreme base. Four others are bunches of tubes which ascend from a common basal part, side by side; lateral fusions common; from 4 to 12 tubes in a bunch. The tubes are cylindrical with some tendency to form enlargements which may be roughly annular, but the surface is fairly even. The cloaca extends throughout the tube; generally with only one (apical and large) cloacal aperture, but in some tubes there are also smaller lateral apertures. Wall of tube relatively thick, one-third to one-quarter total diameter of tube. The tubes range in height from 30 to 120 mm., in diameter from 10 to 23 mm. Color in life, lilac. Sponge firm but somewhat compressible and elastic; tough.

Dermal membrane, where uninjured, is finely and uniformly porous; pores in the meshes of the dermal reticulum. The usual abundant small afferent canals are seen beneath the dermal membrane, giving the surface a vaguely porous appearance. Wall of cloaca covered with the closely set apertures of efferent canals; these apertures not closed in by membrane, 1.5 mm. to a fraction of 1 mm. in diameter. Sponges, taken in February, are full of embryos.

The main skeleton includes ascending primary fibers which curve outward toward the surface, branching as they go, thus becoming radial. Between these are stretched primary connectives, the arrangement producing large squarish or rectangular meshes visible to the eye about 300–600 μ wide. These meshes are subdivided into smaller ones, 100–200 μ wide, by reticula of finer secondary connectives. Primary fibers close to cloacal wall, about 120 μ thick, diminishing to a thickness of 100–50 μ as they approach outer surface, usually less than 50 μ thick at the surface. Except at the surface the spongin of the fibers is very abundant, the spicules chiefly but not absolutely confined to a loose core about one-third the thickness of the fiber. At the surface, while the fibers remain plurispicular, the spongin is comparatively scanty.

The primary connectives are like the main fibers, although in general somewhat slenderer, 70–100 μ thick. The secondary connectives are slenderer than the primary, grading down to a thickness of about 12 μ; spongin abundant, spicules forming a core one to a few rows wide.

Fibers of dermal skeletal reticulum for the most part very slender, 10–28 μ thick, ranging from unispicular to such as contain a few rows of spicules; spongin abundant. Thicker fibers may actually form a part of this reticulum but most of the thick fibers seen in surface view are subdermal. Perhaps the precise condition in any one spot is not constant during growth changes. Meshes of dermal reticulum mostly 175–350 μ wide, 4-sided or polygonal. From the fibers of the reticulum, not only at the nodes but between them, short tufts of spicules project radially outward. Some of these represent the ends of radial skeletal fibers, but others do not. They all project just beyond the dermal surface and include from 2–3 to a considerable number of spicules.

The spicule is a small slender oxea, 80 by 3 μ.

The habitus, regularity in arrangement of the main fibers and primary connectives, thickness of fibers, character of fiber, size of oxea, all show that the *Albatross* sponges can not be separated from *Siphonochalina crassifibra* described by Dendy (1889) from the Gulf of Manaar (Ceylon). There is only one point of difference. In Dendy's sponges there are only (numerous) scattered spicules between the primary connectives, whereas in the *Albatross* specimens such spicules are cemented together and form secondary reticula.

This difference in morphogenetic behavior may be looked on as a variable feature. In Dendy's type the main fibers are about 140 μ thick, connectives about 84 μ; oxea 84 by 3.5 μ; color, deep blue.

Dendy (1905, p. 155) proposes to regard *S. crassifibra* as a variety of *S.* (*Tubulodigitus*) *communis* (Carter), recorded by himself (1889, p. 81) and Carter (1881, p. 367) from the Gulf of Manaar, also by Ridley (1884, p. 401) from Port Jackson, Australia. For this form Ridley gives the primary fibers as only 35–42 μ thick; oxea 100 by 5 μ. Dendy more recently (1916*b*, p. 114) has recorded *S. crassifibra* from Okhamandal. In these (Okhamandal) sponges it may be noted that the primary fibers are only about 50 μ thick, a close approach to *S communis.* Dendy (1905) touches on the vagueness of the characters which differentiate *S. communis*, *crassifibra* and a number of other *Siphonochalinas.* Row (1911, p. 325) has recorded *S. communis* from the Red Sea.

Genus DACTYLOCHALINA Lendenfeld (1887).

Dactylochalina Lendenfeld, 1887, p. 810 plus *Chalinodendron* Lendenfeld, 1887, p. 819.

Sponges with solid digitate processes, the processes generally cylindrical and slender, often branching and anastomosing, sometimes very numerous. Fibers of skeletal reticulum polyspicular, generally slender. Meshes of reticulum remarkably large.

In Lendenfeld's classification (1887) of the Chalinine sponges, *Chalinodendron* is distinguished from *Dactylochalina* chiefly by the reticular appearance of the surface ("mit netzförmiger Oberflächen-Structur"). This would seem to be a secondary feature dependent on the large size of the skeletal meshes, and these in both genera are large, varying from 200 to 300 μ in width in *Chalinodendron*, from 130 to 400 μ in *Dactylochalina.*

The fibers are polyspicular and generally slender in both genera, but slenderer in *Dactylochalina*, in most species of which, but not invariably, there is no noteworthy difference in thickness between the main fibers and the connectives. In some of the *Chalinodendron* species (*C. exiguum* and *C. minimum*), however, the fibers (50 μ) are no thicker than in some of the *Dactylochalinas*, and in one species (*C. exiguum*) there is no noteworthy difference in thickness between main fibers and connectives.

The spicules are somewhat, or considerably, larger in *Chalinodendron* than in *Dactylochalina*, but in *C. ramosum* they are only 110 by 5 μ and in the *Albatross* form, described below, and which is obviously very close to *C. exiguum*, they are still smaller, 100 by 4 μ. Among the *Dactylochalina* species, we find spicules 100 by 3 μ, 90 by 2 μ, 67 by 4 μ, 60 by 2 μ.

In both genera the sponges are digitate, the processes generally but not invariably slenderer in Chalinodendron than in Dactylochalina.

Lendenfeld later (1888, p. 102) modifies his earlier definition of *Chalinodendron*, inserting the presence of conuli among the characters. But the conuli are small, indeed must be very small in the slenderer species.

It seems to be advisable to combine the genera. *Dactylochalina*, so understood, will even then probably run over into *Pachychalina*, but, as is well known, Chalinine sponges are so "plastic" that their division into genera is especially difficult.

DACTYLOCHALINA EXIGUA (Lendenfeld), var. SAMARENSIS, new variety.

Plate 42, fig. 1.

Chalinodendron exiguum LENDENFELD, 1887, p. 819.

Three specimens from a coral reef near Catbalogan, Samar.

Sponge consists of very many, long, slender, cylindrical, dichotomously branching and freely anastomosing processes, 2–3 mm. thick and reaching 150 mm. in length. These processes or "shoots" form a loose mass 100–150 mm. in diameter. When such a mass is disentangled it is found that anastomoses are so common as to give the sponge a somewhat retiform appearance. Whether the primary shoots which may be distinguished in such a mass were all originally derived from a single basal one, can not be told. It is at least possible that this is not the case but that branches of neighboring individuals fuse indiscriminately with one another as well as with their sister-branches.

Sponge is slightly hard to the touch, but both compressible and flexible, not rigid enough to stand erect in the air, but in nature perhaps upheld by the water and waving about in it. Color now, whitish-brown.

Surface smooth, presenting, very distinctly with a lens, a reticulated appearance, due to the large meshes of the dermal skeleton. Sponge partially macerated. Oscula and pores?

Skeletal reticulum composed of fibers 40–50 μ. thick, with large meshes which very commonly are 300–500 μ., but which range from 175 to 600 μ. in width. In the ectosomal region, while there are very many large meshes, small meshes are commoner than elsewhere. From the axial part of the sponge main fibers curve upwards and outwards, becoming radial near the surface, where they frequently project slightly. Between these there are transverse connectives. If the section be taken through the axis of a stem, the skeleton shows considerable regularity. All fibers, main and connectives, of about same thickness; contain many rows of spicules, which about fill the fiber; spongin moderately abundant. Free spicules are scattered between the fibers.

The dermal skeletal reticulum, which is only the outermost part of the general skeleton, is composed of tangential fibers like those of the interior and forming large polygonal meshes like those of the interior. The ends of the radial fibers, which project only slightly or not at all and which lie at or between the nodes of the reticulum, are observable in surface views.

The oxea is smooth, slightly curved, sharp pointed, 100 by 4 μ with smaller sizes.

Holotype.—Cat. No. 21258, U.S.N.M.

The sponge evidently differs but little from the type (Lendenfeld, 1887, p. 819; the author's reference to fig. 65, pl. 26, is probably a *lapsus*, since the figure does not correspond to the description), which is from the east coast of Australia, and the chief characters of which are given as follows: A bunch of branching processes, 3 mm. thick and 60 mm. long, showing some oscula 400 μ in diameter; meshes of skeletal reticulum 290 μ wide (probably the common mean is meant); fibers 50 μ thick, connectives not differing from main fibers in any noteworthy degree; *oxea, straight, 150 μ by 8 μ;* scattered spicules between the fibers.

Subfamily PHLOEODICTYINAE.

Phloeodictyina CARTER, 1882, p. 117.
Phloeodictyinae RIDLEY and DENDY, 1887, p. 31.—Part DENDY, 1905, p. 165.—DENDY, 1921*b*, p. 44.

Sponge body provided with fistular outgrowths. Characteristically the ectosomal skeleton is much denser than the choanosomal, constituting a sort of rind. Microscleres in shape of sigmas or toxas may be present.

Lundbeck, 1902 (p. 56), dissolves Carter's group and distributes the genera. (See George and Wilson, p. 153.) His example has been followed by Topsent and others. Dendy (1905) retains the group to include *Phloeodictyon*, *Oceanapia*, *Histoderma* (now *Coelosphaera*), *Sideroderma* (=*Siderodermella* Dendy 1921*b*), and *Amphiastrella*, which necessitates placing it in the Desmacidonidae. *Rhizochalina sens. str.* (Lundbeck 1902, p. 56), to cover *R. oleracea* O. Schmidt and *R. carotta* O. Schmidt (Schmidt, 1870, pp. 35–36), is referred by Lundbeck to the Chalininae because of the "solid spongin fibers filled with a large number of very small oxea." Dendy (1905) accepts this reference, while Topsent more recently (1920*d*, p. 2) would assign the genus to the Gelliinae. But the general anatomy of Schmidt's two species is such that they might logically be referred to the Phloeodictyinae. This is the opinion of Dendy in his latest memoir (1921*b*, p. 45).

Lundbeck, 1910 (pp. 28–29), again criticises the subfamily and believes the anatomical resemblances are features which have been independently acquired, thus interpreting them as instances of convergent evolution. Dendy in his recent memoir (1921*b*) admits this so far as to separate the non-cheliferous, haplosclerid, genera from *Coelosphaera* (=*Histoderma*) and its allies.

Genus PHLOEODICTYON Carter (1882).

Phloeodictyon Carter, 1882, p. 122.—Lundbeck, 1902, p. 56.
Rhizochalina part, Ridley, 1884, p. 419.—Ridley and Dendy, 1887, p. 32.—Part, Topsent, 1894*c*, p. 6.
Oceanapia part, Dendy, 1894, p. 248.

Spongin usually present, but the skeleton is not a reticulum of distinctly chalinine spiculo-fiber, as in *Rhizochalina sens. str.* Megascleres, oxeas varying to strongyles. No microscleres.

PHLOEODICTYON PUTRIDOSUM (?Lamarck, species).

Rhizochalina putridosa (?Lamarck, species) Ridley and Dendy 1887, p. 33.

A fine large specimen from station D5355 is referable to this species. It is spheroidal, 115 mm. in diameter. As in the *Challenger* specimens the fistulae are numerous (about 40) and rise vertically upward from the upper and lateral surfaces, facts which sufficiently mark off the species from the more commonly recorded *P. fistulosum* (Bowerbank), the original types of which came, like those of *P. putridosum*, from Australian waters. In the *Challenger* specimens the lower surface is 'almost without trace of fistulae'; in the *Albatross* sponge it shows some small apertures, about 3 mm. in diameter, which possibly indicate the presence in the uninjured sponge of small root fistulae. In the *Challenger* specimens, 93–137 mm. in diameter, the fistulae, 6–12 mm. in diameter, were nearly all broken off close to the surface; unbroken ones short and closed terminally. The fistulae in the *Albatross* sponge are of about same width; some shorter ones perfect and terminally closed; most are broken off but several are 60–70 mm. long although broken terminally. In the *Challenger* specimens the megascleres are oxeas, hastately pointed, 195 by 13 μ: in the *Albatross* specimen they are similarly shaped oxeas, but smaller, 150–160 by 8 μ.

The *Challenger* specimens were much incrusted with foreign organisms. Likewise the surface of the *Albatross* specimen shows some serpulid tubes, polyzoa, and molluscan shells. But the chief incrustation is a calcareous (nullipore) alga (Corallinaceae). This organism forms a practically solid white calcareous layer, about 5 mm. thick, at the periphery of the entire sponge and is continued down as a thinner lining layer into some of the canals. Over most of the body it now constitutes the outer surface of the mass and from it the fistulae rise up. Only over the upper surface is the smooth outer layer of the sponge itself still preserved, underlaid by the calcareous layer within which, as within a rind, lies the sponge pulp. After treatment with acid, the calcareous layer is seen to be made up of the sponge skeletal reticulum and the branching, apparently cylindrical, body of the alga, which has everywhere grown between the fibers of the reticulum. The alga evidently infests the outer layer of the choanosome, just beneath the ectosome (dermal layer plus what Ridley and Dendy, 1887, call the bast layer). It converts this into a calcareous rind, outside of which remains the sponge ectosome which tends to break and peel off. The completeness of the calcareous rind coupled with the presence of the sponge pulp within it seems to demonstrate conclusively that some of the fistulae must be afferent and others efferent, for they provide the sole channels of connection between the sponge pulp and the surrounding water. Where the ectosome has been left, as on the upper surface of the sponge, it tends to rise up and form low blister-like swellings. The *Challenger* specimens seem to exhibit something of this appearance, in that the surface is said to be " very uneven and covered with numerous bladder-like, almost glabrous swellings."

The *Challenger* specimens and Lamarck's came from Australian waters. The fistulae taken by the *Challenger* in the Atlantic (off Bahia) and the specimen described by Topsent (1892, p. 74) from the Azores are very doubtfully referred by Ridley and Dendy and by Topsent respectively to this species.

PHLOEODICTYON CAGAYANENSE, new species.

Plate 42, fig. 3; plate 48, fig. 10.

One specimen from Station D5423 (off Cagayan Island in the Jolo Sea). Sponge massive, elongated, 60 mm. high, 40 mm. in transverse diameter, incrusted at lower pole with a leathery alcyonarian. There is a firmer cortex about 1 mm. thick, the outer layer of which is smooth and stony. Sponge tissue internal to the cortex, dense but fragile. Surface covered everywhere with very numerous fistular tubes, mostly 1–2 mm. in diameter, a few reaching a diameter of 3–4 mm. The tubes, which are mostly 4–5 mm. apart, are all broken off, the longest projecting only about 2 mm. Wall of the tubes stony, a prolongation of the cortex; thin, only a fraction of a millimeter thick; including a single undivided cavity, which is produced into the interior for some distance, as a more or less radial canal. Color of the sponge in general, light yellowish-brown; sections show that the dermal layer of the cortex is colorless and translucent.

Skeleton of interior, a loose and vague reticulum, in general unispicular, the side of a mesh equal to the length of a spicule. The spicules are united by a little spongin, easily demonstrated in sections mounted in water. In the deeper part of the cortical region, the reticular arrangement is more distinct, the sides of the meshes here being polyspicular and stout, often about 50 μ thick. In the dermal layer of the cortex the spicules are closely packed and parallel to the surface, forming a dermal crust 100–200 μ thick. Skeleton of the fistular wall, essentially a continuation of the cortical skeleton.

Spicules.—Oxea varying to the strongyle (pl. 48, fig. 10). The spicule is cylindrical, curved or somewhat bent, not always symmetrically, and about 200 by 10–14 μ. In the oxea the ends are often quite suddenly pointed but in this matter there is variation, spicules occurring with more tapering points.

The salient characters of the species are the stony surface and the very large number of fistulae.

Holotype.—Cat. No. 21289, U.S.N.M.

Family DESMACIDONIDAE.

Desmacidinae O. SCHMIDT, 1870, p. 52.
Desmacidonidae part, VOSMAER, 1887, p. 348.
Desmacidonidae plus *Heterorrhaphidae* part, RIDLEY and DENDY, 1887, pp. 31, 62.
Poeciloscleridae plus *Haploscleridae* part, TOPSENT, 1894, pp. 3, 6.
Desmacidonidae plus *Haploscleridae* part, DENDY, 1905, pp. 135, 158.
Desmacidonidae plus *Homorrhaphidae* part plus *Heterorrhaphidae* part, LUNDBECK, 1902, 1905, 1910.

The characteristic microscleres are cheloids (chelas and modifications), but forms are included in which these spicules presumably have been lost during the course of evolution.

The subfamilies recognized are the Mycalinae, Phoriosponginae (see George and Wilson, 1919, p. 153), Ectyoninae, together with the Tedaniinae, Desmacellinae, Hamacanthinae, and Merliinae (see previously, under Haploscleridae). Topsent (1913*b*, p. 52; 1919) would add the Stylotellinae (Lendenfeld 1888) for *Stylotella*, *Stylinos* Topsent (restored), and *Semisuberites* Carter (type: *S. arctica* Carter covering *Cribrochalina variabilis* Vosmaer, *Cribrochalina sluiteri* Vosmaer, and perhaps other literature species. Topsent, 1919, p. 4), deleting *Stylaxia* Topsent, 1913.

The status of the subfamilies Tedaniinae, Desmacellinae, and Merliinae, which are not represented among the sponges studied, is as follows:

Subfamily Tedaniinae.

Tedaniinae Ridley and Dendy, 1887, p. 50.

Forms in which the chelas have been lost. Megascleres of two forms, monactinal forming the main skeleton, and diactinal, tylote or tornote, forming the dermal skeleton. Microscleres generally present in the form of rhaphides. Genera distinguished by Ridley and Dendy: *Tedania* Gray 1867, *Trachytedania* Ridley, 1881.

Topsent distinguishes the rhaphides of these forms, as onychetes, from true rhaphides; they, the former, are described, (1913, p. 630) as inequiended and spinulose in a definite fashion. Topsent, 1912 (p. 3), separates species without microscleres under a new genus, *Kirkpatrickia.*

Ridley and Dendy placed the group in their family Heterorrhaphidae. Topsent, 1894*c*, transferred the genera to the Desmacidonidae. Lundbeck, 1902 (p. 1), likewise places the genera in the Desmacidonidae, referring them to subfamily Mycalinae. Hentschel, 1911 (p. 332, and 1912), disposes of them in the same way, except that he merges *Trachytedania* in *Tedania.* Dendy, 1921*b*, (p. 25), also incorporates these sponges in the Desmacidonidae.

Subfamily DESMACELLINAE.

Desmacellinae Ridley and Dendy, 1887, p. 58.

Ridley and Dendy defined the group: "Megasclera all monactinal, stylote or tylostylote. Microsclera sigmata or toxa or both." and assigned the sponges to the Heterorrhaphidae. Genera distinguished by Ridley and Dendy included only *Desmacella* Schmidt, 1870 (*Desmacodes* Schmidt, 1870, is a synonym).

Topsent, 1892 (p. 80), continues to use the subfamily, but adds *Biemma* Gray (1867), which is redefined as having tylostyles and sigmas, and a halichondrioid skeletal framework, whereas *Desmacella* Schmidt (1870, p. 83) is defined as having tylostyles or styles or a mixture of the two forms, with sigmas or toxas or with both together, or with trichodragmas, or with trichodragmas accompanied by either sigmas or toxas, and with a skeletal framework that is fibrous. Topsent recognizes four species of *Biemma* and six species of *Desmacella.* Topsent (1894*c*, p. 6) abandons the subfamilies and transfers the genera to the Esperellinae (Mycalinae).

Lundbeck, 1902, uses the subfamily, placed in the Heterorrhaphidae, to include *Biemma*, *Desmacella*, and *Hamacantha.* *Biemma* and *Desmacella* are used *sensu* Topsent, in that the former is conceived as having a skeletal framework which, if fibrous, is only inconspicuously so; while in *Desmacella* the framework includes well developed fibers.

Thiele, 1903, points out that the name *Desmacella* should be canceled and replaced by *Biemna* Gray, and for *Biemma sensu* Topsent and authors he proposes *Tylodesma.* Wilson, 1904, accepts these nomenclatural changes.

Dendy, 1905 (p. 155), retains the subfamily, placing it in the Haploscleridae, and does not follow Thiele in nomenclature; *Desmacella* is defined as having a *reticulate* skeletal framework. Henschel, 1911, follows Topsent, 1894*c*, in transferring the genera to the Desmacidonidae (Mycalinae); Desmacella is defined as having a reticular skeleton, *Biemma* as having a halichondrioid skeleton. Hentschel, 1912 (pp. 350–354), adopts Thiele's nomenclatural changes, using *Biemna* Gray in place of *Desmacella* authors and *Tylodesma* Thiele for *Biemma* authors. He continues to define the skeleton of *Tylodesma* as halichondrioid, but this distinction from *Biemna* is certainly vague, as is shown by the fact that he is forced to assign to the latter genus not only species with definitely defined fibers but others with only loose tracts of spicules. Topsent, 1913 (pp. 50, 51), accepts Thiele's nomenclatural changes, as do Hallman, 1916, and Stephens, 1921.

Since Thiele's nomenclatural changes have been so generally adopted the name of the subfamily should be changed to Biemninae.

Dendy, 1921*b* (p. 56), brings the case up again. He accepts Thiele's nomenclatural change in so far as it affects sponges like *Desmacidon peachii* Bowerbank, which are thereby renamed *Biemna* Gray (a brief review of the data is given in Wilson, 1904, p. 135), but is unwilling to accept *Tylodesma.* "If there is one thing clear in the whole muddle" he thinks "it surely is that *Tylodesma* is a pure synonym of *Desmacella.*" I can not agree with Dendy that *Desmacella* should be retained, for the following reasons:

Desmacella Schmidt, 1870 (p. 53, also pp. 3, 77), was set up to cover certain new species, two *Hamacanthas* (*johnsoni* and species) and *Desmacidon peachii* Bowerbank. It is therefore in part synonymous with *Hamacantha* Gray, as Vosmaer (1887) pointed out. Schmidt, 1880 (p. 82), withdrew the *Hamacanthas*, but the genus remained in part at least synonymous with *Biemna* Gray, of which *Desmacidon peachii* may fairly be taken, as is now generally done, as the type species. This only leaves Schmidt's new species, *pumilio* and *vagabunda* (Schmidt 1870), as a body for his genus.

None of the species which Schmidt lists is designated as the type and neither of the new species is described in sufficient detail to be recognizable. Lundbeck, 1902 (p. 99), in fact is in doubt whether they even belong in the genus (still called at the time of his writing *Desmacella*). Dendy, with justice, however, picks the first of the new species, *D. pumilio*, as the type, but there is nothing in the diagnosis of *D. pumilio* to distinguish it from *Biemna.* The second species, *D. vagabunda*, however, shows that Schmidt was using *Desmacella* to cover sponges with tylostyles arranged in loose tracts as well as those with tylostyles combined in definite fibers, like *Desmacidon peachii* Bowerbank, for which *Biemna* Gray had already been arranged although it had been lost sight of. *D. vagabunda* might then possibly, in spite of its inadequate description, have been selected by a subsequent author as the type of a genus, *Desmacella sens. str.*, marked off from *Biemna* by the halichondrioid character of its skeletal framework. This step, which was permissible (International Rules of Zoological Nomenclature, article 30, *g*, Proc. Ninth Congress, 1914), but which neither was nor is obligatory, was not taken. Instead the genus, sharply enough conceived by Topsent, 1892, but given a name (*Biemma*) which had to be withdrawn, was designated by Thiele *Tylodesma.* To bring in again the unfortunate term *Desmacella*, as Dendy proposes, and employ it at this late date for the genus in question would surely be an unwarranted step.

Tylodesma as a generic name should then stand, if the genus itself stands as a group distinct from *Biemna.* Dendy, 1921*b*, is evidently doubtful whether both genera should be retained. If *Tylodesma* (or, as he would call it, *Desmacella*) is retained, he thinks it can only be on the ground that it lacks the rhaphides (or trichodragmas), which he would make a differential feature of *Biemna.* But to exclude species from *Biemna* because they have no rhaphides would bring more trouble, in that we would run counter to established practice: See Topsent's definition of *Desmacella* (=*Biemna*), 1892 (p. 83); Topsent, 1904 (p. 225); Hentschel, 1912 (p. 353, *Biemna truncata* with no rhaphides), (p. 354, *Tylodesma microstrongyla* with rhaphides). Hallmann, 1916, 1917, also has interesting propositions for the subdivision of this group of species into genera. However, it seems to me that all the species would better be combined in one genus, *Biemna*, within which subgeneric types (see under *Tetilla* for instance) could doubtless be set up. We would thus have a genus of reasonable scope and identical with what Schmidt understood by *Desmacella* after he had excluded *Hamacantha* (1880). For a different set of propositions concerning the grouping of these species, see Hallmann 1916. Dendy, 1921*b*, it may be added, now places them in the Desmacidonidae.

Subfamily MERLIINAE

Merliinae KIRKPATRICK, 1911, p. 51.

Silicious sponges which have acquired a basal calcareous skeleton. The silicious sclerites include tylostyles and peculiar microscleres, clavidiscs, probably derived from diancistron-like or sigma-like spicules. Other microscleres, rhaphides, trichodragmas, toxas, and sigmas occur in the only known form, *Merlia normani.*

Kirkpatrick, 1911, and Dendy, 1921 (p. 51), regard this aberrant sponge as related to the Hamacanthinae, and since they place the latter in the Haplosceleridae, the Merliinae are put there too. The relationship to *Hamacantha* seems to be the basic fact.

Subfamily MYCALINAE

Esperellinae RIDLEY and DENDY, 1887, p. 62.—DENDY, 1905, p. 159.
Esperellinae part plus *Dendoricinae* part, TOPSENT, 1894*c*, pp. 6, 9.
Mycalinae LUNDBECK, 1905, p. 7.—HENTSCHEL, 1911, p. 287.
Mycalinae plus *Myxillinae* part, TOPSENT, 1913, pp. 625, 632.

Skeletal fibers, or spicular tracts, without echinating spicules and not markedly areniferous.

Dendy, 1921*b* (p. 55), proposes to restore the names *Esperella* and *Aegagropila* for genera made to receive certain species which according to recent usage would fall under *Mycale.* In consequence he retains the name *Esperellinae* for the subfamily in place of *Mycalinae.* This is a change in a set of terms which seemed about to establish themselves definitely, and if it is desirable, as Dendy points out, to segregate species of *Mycale*, why not set them off as subgenera?

Genus MYCALE Gray (1868).

Esperella AUTHORS.
Mycale GRAY, 1868, p. 533.—THIELE, 1903, p. 949 (nomenclatural history here given).—LUNDBECK, 1905, p. 23.

Incrusting massive, and erect forms of various shapes, sometimes with considerable symmetry, occur; the form is rarely tubular. Megascleres combined in polyspicular fibers, usually with but little spongin, but the spiculo-fibers may be well cornified and firmly united in reticular fashion. Megascleres monactinal, stylote to tylostylote. The characteristic microscleres are palmate anisochelas; to these may be added sigmas, toxas, trichodragmas, and very small isochelas (possibly young forms of the anisochela), in different combinations.

MYCALE AEGAGROPILA (Johnston).

Halichondria aegagropila JOHNSTON, 1842, p. 119.
Esperella aegagropila VOSMAER and PEKELHARING, 1898, p. 19.

Occurring as a thin incrustation, 350–500 µ thick, on a dendritic alcyonarian taken at stations D5136 and D5145.

The megascleres as a rule form the usual, short, more or less vertical fibers running upward from the base and expanding at the surface in wide brushes. But where the sponge is very thin, the brushes alone stretch from base to surface. The tangential spicules of the dermal membrane are arranged in tracts, several spicules thick, forming a reticulum in which the side of a mesh is about equal in length to a spicule.

The megascleres are subtylostyles or styles, the two forms about equally abundant, 250–280 by 7 µ. The spicule tapers toward the base as well as toward the point, and is often not quite straight.

The anisochelas are 36–50 µ long. In the dermal membrane they frequently occur in rosettes. Young stages are abundant down to minute ones, 4 µ long.

The large toxas reach 160 µ in length and occur singly. Smaller sizes, especially a size about 50 µ long, are much more abundant. These occur singly but also often in bundles, constituting toxodragmas.

The characteristic sigmas are 70–90 µ long; smaller sizes abundant.

The incrustations from the two stations seem to differ slightly, as might be expected. At any rate in my preparations of material coming from station 5145 the very large toxas and the large sigmas are more abundant,, the anisochelas less abundant and smaller, than in preparations of material from station 5136.

Vosmaer and Pekelharing (1898, pp. 19–31) have shown that a number of forms should be combined under this specific name, although there is ground for objection to some of their mergings. The species may be defined as a widely spread one generally occurring as a thin incrustation, in which the characteristic combination of spicules is as given above and in which the skeletal arrangement is, in general, as given above. A full description with references to the literature is given in Vosmaer and Pekelharing's paper. Doubtless many geographical varieties, differing in details, are distinguishable. Perhaps the incrusting sponges which Hentschel describes (1911, p. 296) under *Mycale macilenta*, var. *australis*, from southwest Australia may be regarded as such. In these sponges the tangential dermal megascleres form a thick layer, and a second form of anisochela, 12–20 µ long, differing in some details of shape from the larger ones, is distinguishable. Stephens, 1912 (pp. 32–33), would also continue to distinguish *M. macilenta* from *M. aegagropila*, referring to the former species sponges in which the anisochelas fall in two groups, to the latter those in which the anisochelas are all of one type and scattered singly, not in rosettes. Vosmaer and Pekelharing have, however, laid stress on the variability of the anisochela in their species.

MYCALE EUPLECTELLIOIDES (Row), var. REGULARIS, new variety.

Esperella euplectellioides Row, 1911 (communicated, 1910), p. 333.

Station D5136, a colonial mass consisting of three tubes united laterally and below, outer surface of the tubes bearing numerous lobular projections which give evidence of a tendency to become tubular. Largest tube 200 mm. high, diameter of terminal aperture and middle of body 80 mm., smaller below; this is about the size of the type. Wall of tube thin, in general about 1 mm. thick, thicker in the immediate region of a spine. (See below.)

Station D5145, a colonial mass including three tubes similar to the above; these are fused, in places, laterally and basally. Height of tubes 150 mm., diameter of aperture and middle body in one, 60 mm., in the others, about 40 mm.

Dermal membrane of outer surface of a tube scarcely porous to the eye, but in reality perforated by the abundantly scattered small pores. Lining membrane of inner surface studded with very numerous small oscula, 1 mm. and less in diameter. The thin wall of the tube in some specimens is interrupted by a few rounded gaps, of varying size, several millimeters in diameter; these have smooth edges and are doubtless healed wounds. Sponge flesh whitish, skeletal fibers brown or yellow.

The reticulum of spiculo-fibers which supports the wall is very similar to that of the type, but instead of being irregular is regular in that longitudinal main fibers and connectives are distinguishable. Main fibers ascend, more or less parallel to one another, toward the rim of the vase; they are 3–5 mm. apart. Connectives simple or reticular, often 2–4 mm. apart. The entire reticulum is very coarse, sizes of meshes about as in type.

Outer surface of variety covered with sharp strong spines, commonly about 3 mm. long, which project more or less upward. The spines are oblique branches of the main fibers and have the same structure as the latter. In the type the outer surface is covered with the bare, branching, tree-like ends of the larger fibers. In both variety and type the inner surface of the sponge is comparatively smooth.

Main fibers of the reticulum 500–850 µ thick, connectives thinner. Fibers densely filled to the surface of the fiber with the longitudinally arranged megascleres. Nevertheless the spongin uniting the spicules and covering the whole bundle is sufficiently obvious in preparations. All fibers alike.

Just beneath the dermal membrane at both surfaces the megascleres are gathered into long slender tracts about 50 µ thick, very different in appearance from the fibers of the reticulum; they are of the characteristic *Mycale* kind, showing no or almost no spongin. These tracts are obliquely tangential in position, curving to the surface where they expand, forming loose brushes which also are almost tangential in position.

The megascleres are subtylostyles 300 by 6–7 µ, with many slenderer (probably younger) forms 3–4 µ thick; grouped in the fibers, tracts, and surface brushes, and scattered abundantly in the parenchyma. In the type the spicules are smaller, 157–210 by 3 µ.

The sigmas are 70–90 µ long, about 2 µ thick; abundant in parenchyma and at both surfaces. In the type they are 100 µ long.

The palmate anisochelae are 28–30 µ long, in rosettes and singly; common in parenchyma and at both surfaces. In the type they are 26 µ long, and do not occur in rosettes.

Holotype.—Cat. No. 21273, U.S.N.M.

The type is from the Sudanese Red Sea. The reticulum of fibers which supports the sponge wall is irregular, not divisible into primary and secondary fibers, and the outer surface is rougher than in the *Albatross* sponges.

Mycale fistulata Hentschel (1911, p. 292), from Shark's Bay, Southwest Australia, may be listed as another variety of this species. The tubes approach in size the smaller *Albatross* specimens. They fuse laterally. Thickness of wall not given, but evidently thin. Small oscula are distributed over the inner surface. The skeletal reticulum is regular and like that of the *Albatross* variety, but there are no spines, the surface of the sponge being smooth. The subtylostyles are closer in length to variety *regularis*, but in thickness to the type. The anisochelae are 24–26 µ long, the sigmas only 42–65 µ long.

Neither Row nor Hentschel mentions ectosomal tracts and brushes such as occur in the *Albatross* sponges. These structures have some interest as representing a remnant of the characteristic *Mycale* skeletal arrangement, from which the reticulum of well-cornified fibers departs so widely. A reticulum of this general kind, made up of cornified spiculo-fibers firmly combined, is not pecular to *M. euplectellioides*. It occurs in a few other species: *M. nuda* (Ridley and Dendy, 1887, p. 70) and *M. imperfecta* (Baer, 1906, p. 20).

Genus MYXILLA O. Schmidt sensu Lundbeck (1905).

Myxilla O. SCHMIDT, 1862, p. 71. Not *Myxilla* TOPSENT, 1892, p. 108, 1894*c*, p. 11, 1904, p. 168.—Emended LUNDBECK, 1905, p. 131.—KIRKPATRICK, 1908, p. 27.—TOPSENT, 1913, pp. 623, 625.—HENTSCHEL, 1914, p. 97.

Myxilla part, RIDLEY and DENDY, 1887, p. 128.—DENDY, 1895, p. 29; 1905, p. 168.

Dendoryx GRAY plus *Lissodendoryx* TOPSENT part, TOPSENT, 1892, p. 97; 1894*c*, p. 9; 1904, pp. 172, 173.

Habitus varying; incrusting, massive, lamellate, club-shaped forms all occur. Main skeleton a polyspicular reticulation of monactinal megascleres, sometimes very diffuse; fibers differentiated in some species. Skeletal spicules generally spinose styles, sometimes smooth. Special ectosomal megascleres present; these ordinarily diactinal and most often smooth but sometimes spinose. Microscleres isancoras, most often tridentate, to which sigmas may be added.

The generic synonomy is involved. *Myxilla*, as used by Ridley and Dendy, 1887, and Dendy, 1895, 1905, is placed in the Ectyoninae but is conceived as intermediate between the Mycalinae and Ectyoninae, including species both with and without echinating spicules. Dendy would regard the former as the primitive forms, the latter as derived forms in which the spined styles (tylostyles) have been retained although they have lost their original echinating arrangement and "have passed into the main skeleton" forming a reticulation with one another. A necessary corollary is to draw the further deduction that in some species the megascleres have lost their spines.

From this very comprehensive genus Topsent, 1892, 1894*c*, 1904, subtracts the species without echinating spicules (mycaline), leaving *Myxilla* as a distinctly ectyonine genus. For the mycaline species with spined megascleres he restores *Dendoryx* Gray and for those with smooth megascleres establishes Lissodendoryx.

It was pointed out by Dendy, 1895 (p. 29), and by Thiele, 1903 (p. 953), that *Dendoryx* as used by Topsent is not defensible from the nomenclatural standpoint, since the type species of *Myxilla*, *M. rosacea* (Lieberkühn), has no special echinating spicules and is a *Dendoryx* in the sense of Topsent. If, therefore, Topsent's subdivision of *Myxilla* is carried out, the name *Myxilla* must be used instead of *Dendoryx*, and some other generic name or names be found for the ectyonine species of *Myxilla* in the sense of Ridley and Dendy, and Dendy. Lundbeck 1905, followed by others (Kirkpatrick, Hentschel, Topsent), introduces the nomenclatural change of *Myxilla* for *Dendoryx*.

As to the ectyonine species of *Myxilla* in the sense of Ridley and Dendy, Topsent, 1913 (p. 623), refers some to *Stylostichon* Topsent, others in which the skeleton is reticulate to *Dendoryx* Gray emended, used in the sense of *Myxilla*, Topsent olim. According to this proposition, the names, *Myxilla* and *Dendoryx*, of Topsent's classification would simply be interchanged.

Lundbeck and Levinsen (Lundbeck 1905, pp. 2–7) find that ancoras and chelas are sharply separated—that is, there are no transitional forms. On this basis they would separate genera with ancoras from those with chelas. Lundbeck applies this principle, accepted by Kirkpatrick, Topsent, Hentschel, George and Wilson (1919), to the case of *Myxilla* (*Dendoryx* formerly) and *Lissodendoryx*. These two genera intergrade with respect to the character (spinulation or smoothness of megascleres) on which they were originally separated by Topsent. Lundbeck redefines them on the basis of the microscleres, assigning species with ancoras to *Myxilla*, species with chelas to *Lissodendoryx*.

Considering the very great resemblance between *Myxilla and Lissodendoryx tawiensis* of this paper, and other similar cases, I wish to say that it seems to me artificial to place such species in different genera. It would be preferable, to list the two sets of species as subgroups of *Myxilla*, frankly defining them as groups based on a single character and therefore probably artificial. Rather, however, than disturb at present this current tendency in classification, I make use of the two genera.

MYXILLA CRUCIFERA, new species.

Plate 42, fig. 5; plate 49, figs. 3, 4.

Station D5168, one specimen. Sponge a concavo-convex lamellate fragment, about 40 by 50 mm. and 5–8 mm. thick. The convex surface bears the oscula, 1–2 mm. in diameter and 2–4 mm. apart, from which the main efferent canals, about as wide as the oscula, extend radially inward. The concave surface is very irregular, presenting a cup-like depression; dermal membrane of this surface uniformly perforated by the closely set pores. Through this sieve-like membrane the main afferent canals, less than 1 mm. in diameter and about 1 mm. apart, may be seen extending radially inward, thus making the impression of pore areas separated by nonporous tracts. Color, light brown; sponge firm.

Main skeleton a polyspicular reticulum formed by smooth styles; meshes 3 or 4 sided; side of a mesh about equal to the length of a spicule; bundle forming the side frequently includes 6–8 spicules but the number ranges down to two or three. Spicules bound together at nodes of reticulum by a little spongin. Bundles of spicules forming the radial sides of the most superficial meshes very commonly project slightly. Sides of the meshes in the interior may be so aligned as to give rise to continuous, but inconspicuous, tracts; best developed of these are radial to the surfaces and help to bound the main canals.

The ectosomal megascleres, slender tornotes, are abundant; tangentially and radially arranged at both surfaces of the sponge, the radial spicules slightly protruding and for the most part in closely set divergent brushes. Round the osculà, the tornotes are especially abundant; they here form tangential sheaves.

Spicules.—1. Skeletal style (pl. 49, fig. 3, *a*), smoth, cylindrical, slightly curved near basal end, 270–300 by 18–21 µ.

2. Ectosomal tornote (fig. 3, *b*), smooth, straight, 165–200 by 6–7 µ.

3. Sigma (fig. 3, *c*), 50–70 µ long but ranging down to 10 µ long; the larger abundant in the interior, the smallest common in the dermal membrane as well as in the interior.

4. Ancora (pl. 49, fig. 4, *a*, b), 40 µ long ranging down to 10 µ long; abundant in dermal membrane of both surfaces, present but less abundant in the interior. The spicule is the usual tridentate isancora. There is just a suggestion of an angulation in the middle of the shaft (fig. 4, *a*); alae are longer than the teeth. In an apical view the spicule presents a neatly symmetrical, four-parted, crosslike figure, the shaft with the thin lateral expansion on each side (ala) just opposite the middle tooth and in this view looking not unlike a tooth, the lateral teeth opposite each other. (Compare such figures as 17*b*, pl. 21, Ridley and Dendy, 1887.)

This species is very close in its spiculation to *M. lacunosa* Lambe from the extreme eastern Pacific (west coast of Vancouver Island, Lambe, 1893, p. 70), a massive sponge with sigmas about 19 µ long. In its lamellate character and in respect to the classes of spicules presented, the species also resembles *M. hastata* Ridley and Dendy (1887, p. 134) from the Atlantic coast of South America, but the two are far apart in respect to the size of the megascleres and in some other points.

Genus LISSODENDORYX Topsent emended Lundbeck (1905).

Amphilectus part, AUTHORS.—Part, VOSMAER, 1887, p. 353.

Myxilla SCHMIDT part, DENDY, 1895, p. 29; 1905, p. 168.

Lissodendoryx TOPSENT 1892; 1894*c*, p. 9; 1901, p. 19.—LUNDBECK, 1905, p. 153.—GEORGE and WILSON, 1919, p. 150.

Skeletal framework reticular, including sometimes well-marked fibers, or dendritic; spongin present in variable amount. Skeletal megascleres generally smooth styles, but sometimes spined. Special ectosomal megascleres present; these generally, but not always, diactinal. Microscleres isochelas, never ancoras; these may be accompanied by sigmas, toxas, or trichodragmas.

Lundbeck's (1905) definition needs some slight alterations. Thus the ectosomal (dermal) megascleres are not always diactinal. They are monactinal for instance, at least as a rule, in the species described below, and in *L. tuberosa* Hentschel (1911, p. 327) and *L. styloderma* Hentschel (1914, p. 101). The monactinal form is perhaps, as Hentschel 1911 (p. 328) suggests, the ancestral one, the diactinal forms derived ones. The variations of the spicule in the species described below support this phylogeny. The isochelas are not always chelae arcuatae, but in some species, *L. tuberosa* Hentschel and the species described below, chelae palmatae. The chelas may be accompanied not only by sigmas, but by toxas or trichodragmas. (See Topsent's review of the genus, 1901, p. 19.)

LISSODENDORYX TAWIENSIS, new species.

Plate 42, fig. 4; plate 49, fig. 5.

A specimen from station D5168 (Sulu archipelago, Tawi Tawi group). Specimen broken but apparently including most of the sponge, which has the shape of a curved lamella, attached and thickened at the base and becoming here cup-like. The lamella is 3–4 mm. thick, thinning away toward the upper edge.

Concave face of lamella riddled with closely set pores about 50 µ in diameter. Through the dermal membrane the main afferent canals, extending more or less radially inward, may be seen. They are 1 mm. or less in diameter and about that distance apart. Outer, convex, face of sponge likewise riddled by closely set small apertures, but these are larger and less uniform than on the concave face, varying in diameter from 100 to 800 µ; they are doubtless the oscula. Efferent canals, 1 mm. and less in diameter, extend in radially from this surface, either opening by single oscula or roofed in by an extension of the dermal membrane perforated by several apertures. Embryos are present in the parenchyma, many of them full of short skeletal spicules.

Skeletal framework a rather loose polyspicular reticulum of spinose styles; meshes 3–4 sided, side of mesh about equal to length of a spicule. The spicules forming the side of a mesh number frequently 3 or 4, but the common variation is from 1 to 6; they form a loose bundle. The bundles forming the sides of the meshes are so arranged as to form some continuous tracts of considerable length. The skeletal framework breaks up at each surface into loose bunches of divergent spicules, which project slightly; such bunches are about a spicule's length apart. Spongin scantily present at the nodes of the skeletal reticulum.

The ectosomal megascleres are present at both surfaces, some tangential, others radial and slightly projecting. The radial spicules are not in brushes, but are scattered or in loose groups of a few; they lie along with the bunches of projecting skeletal spicules and between them. There is a difference, but only one of degree, between the two surfaces of the sponge. On the oscular surface, the ectosomal spicules are more abundant and they seem to average a greater length than on the pore surface.

The skeletal spicule (pl. 49, fig. 5, *a*) is a spinose style, slightly curved, 280–350 by 18–20 µ. The spines are mere prickles scattered along the shaft in some abundance, thickly set at the extreme basal end.

The ectosomal megascleres are variable, but always smooth and slender; 150–280 by 4–5 µ. The common type (pl. 49, fig. 5, *b*) is a tylostrongyle in which the basal end, which is the innermost in a radially placed spicule, is slightly tylote. Sometimes (rarely) both ends of the spicule are slightly tylote, but even then one end (the inner) is larger than the other. Sometimes, not often, neither end is thickened, the spicule being a strongyle. On the oscular surface of the sponge it not infrequently happens that the outer end is pointed, the spicule becoming a tylostyle. As said above, the spicules seem to average a larger size on the oscular surface than on the pore surface. On the former, the common range in length is 160–280 µ (15 spicules measured). On the latter, the common range in length is 150–200 µ (15 spicules measured).

The isochelas (pl. 49, fig. 5, *d*) are 14–20 µ long. They are abundant in the interior and in the dermal membrane of both surfaces. I have examined them with an immersion objective (Zeiss) in balsam and water. They are very transparent, but I find them to be chelae palmatae and not chelae arcuatae—that is, the axis is not greatly curved, nor is the ala separated below from the axis by a conspicuous notch, and the tooth is broad.

Toxas (pl. 49, fig. 5, *c*) are abundant close to the dermal membrane and in the interior. The spicule is much bent at the middle and the ends sharp; 150–350 µ long, 2–3 µ thick. Smaller sizes, young stages, are common.

Holotype.—Cat. No. 21272, U.S.N.M.

Genus COELOSPHAERA Wyville Thomson (1873).

Coelosphaera Wyville Thomson, 1873, p. 484.—Dendy, 1921*b*, p. 102.

Histoderma Carter, 1874, p. 220.—Topsent, 1894*c*, p. 10.—Dendy, 1905, p. 166.—Part, Lundbeck, 1910, p. 7.

Body typically spheroidal and phloeodictyine in appearance, with a hard dermal layer made up of closely packed tangentially placed megascleres, and with fistular processes. Typically the megascleres are tylotes, fusiform or subfusiform, varying to strongyles of similar shape; ends occasionally unequal, spicule becoming actually monactinal. In one set of species however the megascleres are cylindrical oxeas varying to strongyles of similar shape. With microscleres in the form of isochelas, accompanied often by sigmas, less often by trichodragmas or toxas.

Dendy, 1921*b* (p. 102), points out that the genus was established in 1873 by Wyville Thomson and that Carter's name *Histoderma* is a synonym and must be retired in spite of its universal currency. Dendy is evidently right and *Coelosphaera* must be used instead of *Histoderma*, since Thomson's sponge, *C. tubifex*, is recognizably described (1873, pp. 484–486, fig. 83). The habitus of this sponge is phloeodictyine; there is a smooth rind; the megascleres are "pinheaded," the microscleres sigmas and isochelas. Dendy concludes, moreover, that Carter's type, *Histoderma appendiculatum*, is specifically identical with this species.

In separating *Coelosphaera* (*Histoderma*) from the haplosclerid phloeodictyine sponges Lundbeck (1910, p. 28) is influenced in part by the fact that the megascleres of such species as *C.* (*Histoderma*) *appendiculata* Carter are fundamentally different from those of *Phloeodictyon*, etc. The spicules of the latter genera are oxeas varying to strongyles, cylindrical and fundamentally diactinal. The magascleres of *C.* (*Histoderma*) *appendiculata* Carter on the contrary are fusiform or subfusiform tylotes, which only secondarily become strongylate; moreover, they show their desmacidine origin in an early ontogenetic stage which is monactinal (Lundbeck, 1910, p. 10). This is convincing. A complication is however effected by the occurrence of species like *C.* (*Histoderma*) *singaporensis* (Carter), *C.* (*Histoderma*) *vesiculata* Dendy, and *C. toxifera* of this report. In these species the megascleres are cylindrical oxeas or strongyles or intermediates, which do not differ from the haplosclerid type of diactinal spicule (Ridley, 1884, p. 421, Lindgren, 1898 p. 297, Dendy, 1905 p. 166). A curious feature, too, is that in them all the megascleres show such a remarkable variation in size, more especially in length. In these species, nothing in the adult spicule suggests a monactinal phylogenetic origin, and while the ontogeny has not been studied in detail, Ridley, 1884, interprets very slender oxeas as young stages in *C.* (*Histoderma*) *singaporensis* and Dendy, 1905, mentions for *C.* (*Histoderma*) *vesiculata* slender hair-like spicules, apparently diactinal, which are probably young stages of the adult sclerites. Thus these species are set off in respect to an important feature from the typical *Coelosphaeras*, and something might be said in favor of their union with the haplosclerid Phloeodictyinae, regarding the latter as forms in which the chelas have been lost. On the whole, however, it seems best not to separate them from the other *Coelosphaeras*, but to regard the cylindrical shape of the megasclere as the culmination of an evolutionary tendency which begins to show itself even in the typical species of the genus. In a revision of genera I suggest that these species be set off from the type as a subgenus.

Topsent, 1894*c* (p. 11), enumerated the species of the genus known at that time. Lundbeck, 1910 (pp. 25–26), has given a more recent list in which, however, some of the forms are referred by him to other genera. He includes *Siderodermа navicelligerum* Ridley and Dendy, for which Dendy, 1921*b* (p. 105), substitutes the new name *Siderodermella*. To Lundbeck's list may be added: *C.* (*Histoderma*) *verrucosa*, var. *fucoides* Topsent from Amboina (Topsent, 1897, p. 452), *C.* (*Histoderma*) *dichela* and var. *gracilis* Hentschel from the Aru Islands (Hentschel 1912, pp. 343, 345).

COELOSPHAERA TOXIFERA, new species.

Plate 42, fig. 7; plate 49, fig. 6.

One dried specimen from station D5640. Sponge massive, 100–130 mm. high with horizontal diameters of 160 and 300 mm. The body, which is covered with a firm rind, bears on its upper and lateral surfaces very numerous (about 75) tubular processes, 5–10 mm. in diameter. The ends of most of these fistulae are broken off but are present in the case of a few, which may be seen to taper somewhat to a rounded closed extremity. The complete fistulae are 30 mm. or less in length. One of them is terminally branched, dividing into three short processes.

What appear to be three cloacal apertures, 20–40 mm. in diameter, lie on the upper surface. These seem to be natural and lead, each, into a depression into which open several canals. The whole under surface is much incrusted; it was evidently attached and is without appendages.

The skeletal framework is made up of strong spiculo-fibers, often 0.5 mm. thick, consisting of closely packed megascleres; spongin almost absent. In the body the spiculo-fibers are combined to form reticular laminae about 0.5 mm. thick, the apertures in which are 0.5 mm. or thereabouts in diameter, while the spiculo-fibers between the apertures are somewhat less than the diameter of the latter. Such reticular laminae are disposed more or less parallel to the surface of the sponge, 1–3 mm. apart. Between them extend trabeculae of spiculo-fiber, forming a coarse, irregular reticulum.

The dermal membrane of the body is very thin, shows no pores, and is filled with closely packed megascleres of all sizes, arranged tangentially. The underlying hard rind is formed by the most superficial of the skeletal reticular laminae; the apertures in this are smaller than in the laminae of the interior.

The fistular processes are hollow. The wall is about 1 mm. thick and consists of a thin dermal membrane, overlying a fairly coarse reticulum of spiculo-fiber. The dermal membrane includes a single layer of tangentially placed megascleres, not closely packed as in the dermal membrane of the body but forming an irregular network, in general unispicular; the 3 or 4 sided meshes about half a spicule length in width; typically each mesh containing a pore.

Spicules.—1. Strongyles (pl. 49, fig. 6, *a*, *b*), cylindrical, smooth, slightly curved, with a typical size of about 360 by 16 μ. From this size the spicules grade down to very small ones, 36 by 10 μ; the smaller sizes are abundant, the intermediate sizes scanty.

2. Palmate isochelas (pl. 49, fig. 6, *c*), 20 μ long, in the interior and in the dermal membrane of the fistular processes.

3. Toxas (pl. 49, fig. 6, *d*), 60–80 μ long, abundant in the membranes of the interior; the degree of curvature varies somewhat, and the curvature is sometimes asymmetrical.

Holotype.—Cat. No. 21340, U.S.N.M.

Subfamily HAMACANTHINAE.

Hamacanthinae Ridley and Dendy, 1887, p. 59.
Hamacantha Gray, Topsent 1894*c*, p. 7.

Desmacidonidae in which chelas as such are not present; characterized by the presence of peculiar microscleres, diancistra.

Genus HAMACANTHA Gray (1867).

Vomerula part, O. Schmidt, 1880, p. 82.
Hamacantha Gray, 1867, p. 538.—Part Vosmaer, 1885, p. 28; 1887, p. 352.—Topsent, 1894*c*, p. 7.—Lundbeck, 1902, p. 9.—Topsent, 1904, pp. 215–224.
Hamacantha Gray plus *Vomerula* Schmidt, Ridley and Dendy, 1887, p. 59.

Habitus varying: massive, erect, incrusting, and papillate forms occur. Skeletal framework consists of polyspicular fibers or tracts, together with scattered spicules, crossing in irregular fashion to form more or less of a network; spongin absent or present in small amount. Megascleres: generally styles, but sometimes oxeas or a mixture of the two; or styles, tylostyles, and strongyles; in some species megascleres of ectosome, exotyles, differ from those of general skeleton, having the shape of strongyles or tylostrongyles with roughened outer end. Microscleres: diancistra; in some species, two or even three forms of diancistron, differing greatly in size, may occur; in addition, toxas, sigmas, trichodragmas or bundles of stouter microxeas may also occur.

Ridley and Dendy, 1887, redefined *Hamacantha* Gray and *Vomerula* Schmidt, making the distinction to lie in the shape of the megascleres, oxeate in the former, stylote in the latter. Topsent, 1894*c* (p. 7), combined the two genera on the ground that the megascleres vary within the same species. Vosmaer (1887) had previously used *Hamacantha* in this extended sense, reserving *Vomerula* Schmidt for forms like *V. tibicen* O. Schmidt (1880, p. 83) possessing diancistra and chelas (Vosmaer lists, as an example, *V. tenda* O. Schmidt, evidently a slip, since the definition shows he had in mind Schmidt's second species, *V. tibicen.* Topsent has recently, 1920*d*, (p. 9) redescribed *V. tenda.*) But since no one has rediscovered forms with diancistra and chelas, Ridley and Dendy's criticism (1887, p. lxvi) of *Vomerula tibicen* Schmidt has been followed, and the species, and with it, *Vomerula* in the sense of Vosmaer 1887, deleted. *Hamacantha* in the present sense remains as the sole genus of the subfamily.

Lundbeck, 1902 (p. 108), enumerates the known species, to which Topsent especially (1904) has added a number of others from the region of the Azores. *Hamacantha* is a genus of sufficient complexity to be set apart from simpler forms such as the Gelliinae, Renierinae, etc., along with which Ridley and Dendy, 1887, classed it. Topsent, 1894*c*, accordingly transferred it to his Poecilosceridae (Desmacidonidae authors). Some others, however, Kirkpatrick, 1911, and Dendy, 1921*b* (p. 25), would retain the genus (or subfamily) in the Haploscleridae.

HAMACANTHA ESPERIOIDES (Ridley and Dendy), var. MINDANAENSIS, new variety.

Vomerula esperioides RIDLEY and DENDY, 1887, p. 60.
Hamacantha esperioides KIRKPATRICK, 1903, p. 253.

One specimen from station D5504 (off the island of Mindanao).

Ridley and Dendy's species was based on a number of large, erect sponges from the South Atlantic (Agulhas Bank and off Rio de la Plata). Surface conulose; dermal membrane reticular to the eye. Main skeleton a coarse reticulum of thick stout spiculo-fiber; dermal skeleton in general a reticulation of spiculo-fiber. Megascleres: styles, smooth, slightly curved, tapering at both ends, 700 by 19 μ. Microscleres: large diancistra 177 μ long and sigmas 38 μ long. A small type of diancistron, regarded as perhaps a young form, of about same length as the sigma is also recorded. *H. esperioides* has also been taken southeast of Cape Colony (Kirkpatrick, 1903, p. 253.)

Lundbeck has shown, 1902 (pp. 101–102), that three classes of diancistra coexist in the same individual in *H. bowerbanki*, differing greatly in size though only slightly in shape (1902 p. 18). Topsent, 1904, likewise finds very small and medium sized diancistra along with the large ones in several species. Lundbeck has, moreover, examined, 1902 (p. 103), *H. esperioides* and finds that the small diancistra recorded by Ridley and Dendy cannot be young forms, but represent a distinct class of spicule.

I refer the *Albatross* specimen to a variety, instead of to the type, because of its difference in form, smaller size of styles, smaller size of sigmas, and absence of the very small diancistra.

The *Albatross* sponge is an amorphous mass 13 by 8 cm., incrusting and surrounding a broken mollusk shell; thickness of sponge 25 mm. and less. Surface is not conulose, but as in the type is conspicuously reticular to the eye, except over the large ectosomal spaces; there are several such, the largest 9 mm. in diameter, roofed in by the nonreticular translucent dermal membrane; some of these open by oscula, 3–5 mm. in diameter; it is uncertain whether they are all efferent. The resemblance in surface appearance to the type (see Ridley and Dendy) is thus close.

The sponge is whitish brown, compressible and easily broken; greatly excavated by canals of considerable size. In general the choanosome reaches the dermal membrane in the shape of narrow trabeculae, between which lie the small subdermal chambers. The trabeculae divide up the dermal membrane into polygonal areas, and thus give to the surface the reticular appearance perceptible to the eye. The dermal membrane is uniformly pierced by closely set pores, 90–180 µ in diameter, although the reticular appearance of the surface suggests the existence of "pore-areas" separated by aporous tracts. In the nonreticular areas of dermal membrane roofing in the larger ectosomal spaces pores occur, as well as elsewhere.

The internal skeletal framework consists of abundant compact spiculo-fibers, looser tracts, and scattered spicules, all crossing in every direction without order. Spicule tracts that are radial to the surface are distinguishable in the superficial part of the sponge. The fibers reach a thickness of 160 µ. Spongin not perceptible; if present at all, there can only be a very little of it. The dermal skeleton in general is an irregular reticulum quite as in Ridley and Dendy's figure, 1887 (pl. 17, fig. 12). Over the larger ectosomal spaces where the dermal membrane is not reticular to the eye, the spicule tracts are either more confusedly arranged or else broken up into scattered spicules.

The styles agree with those of the type except that they are smaller, 470–500 by 12 µ. The large diancistra are like those of the type and of about same size; they commonly have a length of

160–180 μ, smaller ones down to a length of 100 μ occurring sparsely. The very small diancistra of the type could not be found. The sigmas are only 16–18 μ long. The diancistra and sigmas occur abundantly in the dermal membrane and in the interior. No rosettes were observed, the diancistra apparently always occurring singly.

Holotype.—Cat. No. 21269, U.S.N.M.

Subfamily ECTYONINAE

Ectyoninae RIDLEY and DENDY, 1887, p. 128.—TOPSENT, 1894*c*, p. 11.—LUNDBECK, 1905, pp. 1–2.

Desmacidonidae in which the spiculo-fibers of the skeleton are echinated by monactinal, usually spined, spicules. In incrusting forms the corresponding spicules project vertically from the basal skeletal plate.

Genus CLATHRIA O. Schmidt (1862).

Clathria SCHMIDT, 1862, p. 57.—DENDY, 1895, p. 31.—HENTSCHEL, 1911, p. 368.

Clathria SCHMIDT plus *Rhaphidophlus* EHLERS, RIDLEY and DENDY, 1887, pp. 146, 151.

Clathria SCHMIDT plus *Rhaphidophlus* EHLERS, TOPSENT, 1894*c*, pp. 14, 15.

Generally erect sponges. Main skeleton a reticulation of spiculo-fiber usually with much spongin; the fibers include skeletal styles or subtylostyles, generally smooth but in some species more or less spinose, especially at the basal end; fibers echinated by spined styli (acanthostyles). In the ectosome and elsewhere there are usually free stylote megascleres, often slenderer and shorter than the skeletal styles; these may form a radial dermal crust (*Rhaphidophlus*). Microscleres, small palmate isochelas and toxas (or rhaphides), together or separately; microscleres sometimes absent.

Hentschel, 1911, and Hallman, 1912 (p. 205), would include forms in which the echinating spicules are smooth. The toxa, as is known (see Wilson, 1902, p. 398), may vary in the same specimen from the typical shape to that of the rhaphid, both toxas and rhaphides sometimes forming loose bundles. Hentschel has recently (1912, p. 359) drawn attention to this fact.

CLATHRIA FRONDIFERA (Bowerbank), var. SETO-TUBULOSA, new variety.

Halichondria frondifera BOWERBANK, 1875, p. 288.

Clathria frondifera RIDLEY, 1884, pp. 448, 612.—RIDLEY and DENDY, 1887, p. 149.

Station D5136, one specimen. Station D5141, several fragments and two larger specimens.

Primarily in this sponge there are irregularly lamellate branches, bearing ridges and terminating above in free processes which project obliquely upward and are digitate or spinous in shape, up to about 5 mm. long and 1.5–2 mm. in diameter. Branches 1.5–2 mm. thick; thin or often membranous between the ridges. The mode of growth is obviously such that the free processes become confluent, then constituting ridges of a lamellate branch.

It is, however, only in places, chiefly in terminal (younger) parts of the sponge, that independent branches exist. Elsewhere the branches have for the most part fused edgewise to form a tubular structure, 10–25 mm. in diameter, which itself exhibits irregular branching. The inner surface of the tubes is smooth or nearly so, while the outer bears the above-mentioned processes and ridges, the latter in some specimens assuming a very meandriform aspect. The wall of the tube retains the thickness of the original branches and, like the latter, shows many membranous areas (fenestrae). The cavities in the several parts of the tubular structure are by no means all confluent. Some are, but many cavities are isolated as a result of their mode of formation. The cavities open to the exterior above and sometimes below and laterally.

One specimen shows that after the tubular structure has been attained the formation of conspicuous digitate or spinous processes and independent lamellate branches may be practically suppressed, the tubes growing in direct and simple fashion. That is, the whole sponge is in this case tubular, the inner surface smooth, the outer adorned with many meandering ridges and low processes, the wall fenestrated with many membranous areas.

The more or less tubular sponge may grow predominantly in one direction, or in several directions, the largest specimens measuring 110–120 mm. in greatest length. The attachments indicate that the habit is in general repent. The sponge is somewhat compressible but firm; color in alcohol, a very light brown. The membranous fenestrae show better after drying.

Pores in the meshes of the dermal reticulum. Doubtless very small scattered apertures are the oscula.

The skeletal reticulum of spiculo-fibers is close with rounded or elongated meshes. Main fibers longitudinal, 80–120 μ thick, the included styles forming a core surrounded by abundant spongin; the included styles belong both to the stout and slender skeletal forms. These fibers are less than the length of a skeletal style apart. Connectives like main fibers but in general slenderer with fewer rows of spicules.

Spicules.—1. Skeletal styles. (*a*) Stout form, smooth, slightly curved, 180 by 10 μ to 250 by 12 μ. (*b*) Slender form of about same length but only 6 μ or thereabouts in thickness.

2. Acanthostyles, 50–75 μ long. Head and shaft spinose, but usually a region next the head is bare or less spinose than the rest of shaft.

3. Long slender dermal styles, 200–250 by about 6 μ, are scattered tangentially in the dermal membrane. Very commonly the head is perceptibly spinose at a magnification of 600; in other spicules the spinulation is absent or not perceptible at this magnification.

4. Small dermal styles, 80–100 by 4–5 μ, the head slightly tylote and minutely spinose; radially projecting, abundant. These and the underlying tracts of longer tangential dermal styles make a dermal reticulum with meshes 100–120 μ wide.

5. Isochelae 10–12 μ long, at surface and in interior; abundant. No toxas were found. The horny fiber sometimes splits off slender shreds which at first glance look like toxas.

Holotype.—Cat. No. 21256, U.S.N.M.

The *Albatross* sponge, along with several others, is certainly close to *C. frondifera* (Bowerbank) from East Indian and Australian waters. Ridley, 1884 (p. 449), doubtless refers to the tendency in this species to become tubular when he says that the branches anastomose freely "forming a number of deep angular cells, open above and below and more or less at the sides also, owing to the fenestrae left between the branches." The type has toxas and lacks the small radial dermal styles. The distribution to date is given in detail in Ridley and Dendy 1887 (p. 149).

Topsent 1892*b* (p. 3), records the species for the Red Sea. Lindgren 1898 (p. 309), records it for the Sea of Java. Dendy (1905) (p. 170), records the species for Ceylon and merges in it *C. corallitincta* Dendy (1889), also from Ceylon. He adds that "the slender styli or tylostyli may form a fairly distinct dermal skeleton, in which they are either irregularly scattered or arranged in more or less definite radiating brushes. The bases of these spicules are sometimes minutely spined." Dendy somewhat later, 1916*b* (p. 128), while inclining to regard *C. frondifera* as "a very variable and widely distributed species," again sets up *C. corallitincta* as a separate species, but still later 1921*b* (p. 65), adds: "I am not at all sure that the distinction between this species and *Clathria procera* (Ridley) can be maintained, and both may be merely varieties of *C. frondifera*." Dendy, 1916 (p. 128), mentions the presence of large pseudoscula on prominent parts of his *C. corallitincta* which would thus seem to share in the tube-forming habit.

Hentschel, 1912 (p. 360), records the species from the Aru Islands, and notes that his specimens are in places tubular. He distinguishes from the type two new varieties, one of which, variety *dichela*, has small subtylostyles of about the same size as spicule (4) in the *Albatross* sponge, but it has also toxas and two classes of isochelas. Hentschel gives the types as having "Keine Rinde," but in one of his varieties (*major*) he finds that "eine dünne Rinde aus ungeordneten Nadeln ist vorhanden." Doubtless the armature of dermal spicules varies a good deal within the species.

Thiele, 1903 (p. 958), has studied a specimen which is certainly very close to, probable identical with, the *Albatross* form. Thiele's sponge, from Ternate, he remarks is very similar to *C. frondifera* (Bowerbank). He refers it to *Rhaphidophlus filifer*, variety *spinifera* Lindgren (1898), but erects Lindgren's variety into a species. This identification would seem to be questionable, since Thiele's sponge includes in its dermal "crust" a small style not mentioned by Lindgren. The spiculation of Thiele's sponge (1903, fig. 23) is very close, except in the presence of toxas, to that of the *Albatross* variety, and in its habitus it resembles the growing parts of the latter in which independent branches are distinguishable.

The data indicate that in *C. frondifera* we are dealing, as Dendy has suggested, with a widely distributed and variable species. Among the variable structures we must include the dermal skeleton, which may be present in a highly developed state (var. *setotubulosa*) or only as a fairly distinct structure lacking characteristic spicules (Dendy's specimens of the type, 1905, p. 170, see previously), or it may be so inconspicuous (absent?) as to have escaped mention. If this series of forms is correctly interpreted as a group of varieties, *Rhaphidophlus* Ehlers in the usual sense (to which the variety here described, considered by itself, would be referable) can not be maintained. And, indeed, since Dendy, 1895 (p. 31), it has been generally, although not always, merged in *Clathria*. Recently Hallmann, 1912 (p. 175), would restore the genus, using it, however, in a special sense to include only species in which the projecting dermal styles are *of a special kind*, namely, derivatives of the echinating styles and typically shorter than the latter. I suspect that this definition is too precise to be of use in practice. Topsent (1920*d*, p. 17) is willing to restore the genus practically in its old sense.

CLATHRIA FASCICULATA, new species.

Plate 42, fig. 6; plate 49, figs. 7, 8.

One dried specimen from Togian Bay, Togian Island, Gulf of Tomini, Celebes.

The sponge is of fruticose appearance, branching and expanding from the attached base upward; the branches, commonly about 15 μ thick, anastomose freely with one another. Height of the whole mass 230 mm., greatest width 170 mm. Color, grayish red.

The surface is covered with closely set conuli, singly or in ridges, between which there is smooth membrane. Oscula 4 mm. and less in diameter, scattered over the sponge. Pores closed. Subdermal cavities underly the smooth parts of dermal membrane.

Skeletal framework consists of ascending main fibers which are compound (fascicled) and an intervening large-meshed irregular network of simple fibers. The main fibers are 300–500 μ thick and about 1–2 mm. apart. Each is made up of several compact elementary fibers, or funiculi, 50–100 μ thick, which lie close together, less than a spicule's length apart; the funiculi fuse with one another here and there, and are moreover connected together, sometimes by scattered spicules but more generally by small spicular bundles that are placed well apart from one another. The branches of the main fibers diverge in obliquely radial directions and pass singly into the conuli, where the funiculi are more intimately fused than elsewhere. The fibers consist of closely packed smooth styles and a little spongin; spongin not showing, or barely showing, on the outside of the funiculi. They are echinated with acanthostyles, but in many places very sparsely, perhaps owing to imperfect preservation.

The reticulum which stretches between the main fibers, is made up of simple fibers 50–85 μ thick. The meshes vary in size and shape, characteristic ones measuring 175 by 175 μ, 200 by 350 μ, 300 by 350 μ, 250 by 500 μ. The fibers are made up of closely packed smooth styles and some spongin; there is little or no spongin on the outside of the fiber, except at the nodes and round the bases of the acanthostyles. The echinating acanthostyles are fairly common in some regions, sparsely scattered in others; the differences may be due to the preservation.

Spicules.—1. Skeletal style (pl. 49, fig. 7), smooth, slightly curved, 200–280 by 8–12 μ; closely packed in skeletal fibers.

2. Dermal style (pl. 49, fig. 8, *a*, *b*), smooth, nearly straight; a great many about 100–120 by 3 μ, but they run up to 200–300 by 5–6 μ. Abundant in the dermal membrane, where they occupy, in general, a tangential position; over the conuli, they project radially, forming a furze, and elsewhere they may project in diverging tufts (bouquets), although not densely enough to form a furze.

3. Acanthostyle (pl. 49, fig. 7), 70–80 by 6 μ; head spinose and slightly enlarged; part of shaft near head usually less spinose than the distal half.

4. Isochela (pl. 49, fig. 8, *c*), palmate, small, 14–16 μ long, fairly abundant in the dermal membrane and in the membranes of the interior.

5. Rhaphides, as long as 200 μ but variable in length, although always long and slender; slightly bent or curved in irregular fashion;

usually separate, but sometimes in groups as trichodragmas; rarely occurring in the shape of the toxa.

Holotype.—Cat. No. 21326, U.S.N.M.

In some other species of *Clathria*, the skeletal framework has differentiated in the same general direction as in *C. fasciculata*. Thus Hentschel (1911, p. 364) describes a form (not named) in which the skeleton is made up of spicular bundles which ascend like pillars and between which is suspended, so to speak, a network of delicate horny fibers. And in *C. elegantula* (Ridley and Dendy, 1887, p. 149; Hentschel 1911, p. 372) there are ascending columns between which stretches a reticulum of fibers. But in these forms the columns and pillars are not fascicled.

Family AXINELLIDAE.

Axinellidae Ridley and Dendy, 1887, p. 166.

Sponge body ordinarily more or less upright, of a branching, lamellate, or cup-like habitus. But massive and even incrusting forms occur, the latter perhaps representing a developmental phase. Skeleton typically consists of ascending bundles of spiculo-fibers, from which arise subsidiary fibers which radiate to the surface. Skeletal fibers without spined echinating spicules and typically plumose. The characteristic megascleres are monactinal. In addition to these, diactinal megascleres may also occur and in some genera are the only form. Microscleres in the shape of microxeas (to include the acanthoxeas of some forms), trichodragmas, or sigmas occur in a few genera; cheloid microscleres do not occur.

Following Dendy (1905, p. 182), certain sponges with axinellid characters but with asters (*Vibulinus*, for example) have been generally transferred to the Astraxinellidae (in the *Hadromerina*), although Dendy himself now gives up this group. Topsent (1894*c*, p. 2, 1897; *b*, p. 249) had already transferred *Raspailia* to the Ectyoninae, a move that has been uniformly followed, *Syringella* being looked on as a subgenus of *Raspailia*. Even with these exclusions, Dendy, 1905 (p. 182), regards the family as ill-defined and probably polyphyletic. More recently, 1916*b*, he would delete the family, including the genera in the Haplosceridae. Still later, 1921*b*, he would retain the group as a subfamily in the Desmacidonidae. Doubtless there are good phylogenetic arguments underlying these proposed changes, but when one considers how little we know of the ontogeny and the heredity-variation phenomena of sponges, it must be confessed that the value of any considerable change in a generally accepted scheme of classification is at present problematical.

Over 30 genera have been enrolled in this family, but with respect to several there is little reason why they should be put here. With the exclusion of these, a good group is left centering round such forms as *Axinella*, *Phakellia*, *Acanthella*, and *Auletta*, which seem to be related, through *Raspailia* and *Axinella*-like species with a few acanthostyles (*Axinella acanthifera* George and Wilson, for instance, which I now think would best be transferred to *Raspailia*), to the Ectyoninae (Dendy's original position, see George and Wilson, 1919, p. 161). Hallmann, 1916, 1917, and Dendy, 1921*b* have recently discussed a number of the genera and their classification.

Genus AXINYSSA Lendenfeld (1897).

Axinyssa LENDENFELD, 1897, p. 116.

Axinellidae with conuli; skeletal spicules, oxeas. No microscleres.

Lendenfeld's diagnosis, 1897, reads "massive axinellidae," but the species described below has a large apical cloacal cavity. Other species of the genus have been described or recorded by Kirkpatrick, 1903 (pp. 245, 246), and by Topsent, 1906 (p. 7).

Thiele, 1903 (p. 934), thinks it advisable to confine the axinellidae with oxeas (amphioxeas) to the following three genera: *Dactylella* Thiele, *Axinyssa* Lendenfeld, *Phycopsis* Carter. This rule, if rigidly followed out, would necessitate the removal from *Axinella*, and possibly other genera, of certain species that have been placed there. A distinction should probably be made between equiended and inequiended oxeas. The latter form is close to the style, and species with it might well be left in *Axinella*.

AXINYSSA ACULEATA, new species.

Plate 42, fig. 8; plate 49, fig. 9.

Two specimens, one (dried) from station 5254, the other from station 5641. The illustrations were made from the former specimen, which happened to be studied first.

Both specimens massive, attached below, with a large apical cloacal cavity, which is coextensive or nearly so with upper surface of sponge. In the dried specimen the horizontal diameter of the whole sponge is 140 mm., height 120 mm.; cloacal cavity 70–100 mm. wide and about 60 mm. deep. The other specimen is something over half as large, with a cloacal cavity that is relatively somewhat wider. Sponge firm but not hard. Color, brown.

Both surfaces, outer and cloacal, covered with minute, sharp spine-like conuli, which in general are connected with fine ridges; conuli

0.5 to something over 1 mm. high, 0.5 to 1 mm. apart. The outer surface of sponge is roughened by numerous elevations, which in the alcoholic specimen are irregular in shape, but in the dried specimen are short subcylindrical lobes projecting upward and outward; such lobes are mostly 10–15 mm. high and about 5 mm. in diameter, grading away into slight irregular protuberances. Surface of cloaca lacks the elevations which make the outer surface so uneven.

A few pores are distinguishable in the alcoholic specimen; doubtless most are closed; the open pores are scattered over both surfaces, where they perforate the thin dermal membrane and lead directly into the subdermal cavities which are of moderate size. Oscula 1 to 4 mm. in diameter are scattered over both surfaces; they are larger and more abundant in the dried specimen than in the other.

Skeletal framework consists of ascending spicular tracts interwoven so as to form a loose irregular reticulum which nearly fills the whole sponge body, breaking up close to each surface into short obliquely radial tracts which enter and support the conuli and connecting ridges. The spicules of a radial tract separate so that a conulus contains a very few spicules, usually only two or three and sometimes only one (pl. 49, fig. 9). Spongin very scanty and the tracts of the main skeleton thus not well defined; these tracts 150–250 μ thick and crowded, the meshes between them often 300–400 μ wide, longer than wide. Between the tracts of the main reticulum lie scattered spicules, which close to the surface may assume a tangential position, thus extending between the radial tracts where the latter enter the conuli. The short radial tracts of this species may be taken to represent the radial fibers of axinellids in which the skeleton is distinctly differentiated into an axial part and a peripheral part.

Spicules.—Oxea (pl. 49, fig. 9), equiended, cylindrical, smooth, slightly curved, sharp pointed; 1000–1500 by 30–40 μ. Slender, young forms of course occur. A very few styles occur, intermingled with the oxea, but no more than might be expected to occur through variation in any sponge with diactinal megascleres. Another variation occurs, rarely, in both specimens; in this type the oxea is not evenly curved, but is sharply, although not much, bent at some point which is usually not the middle, the spicule hence asymmetrical. A third variation, which may be looked on as an intensification of the last occasionally occurs in one (the dried) specimen; the oxea of this type is curved at several points, thus becoming serpentine; such spicules were found in the interior, perhaps serving as binders; they correspond to smaller sizes of the typical spicule, a characteristic one measuring 500 by 10 μ.

Foreign spicules (small raphid-like oxeas, sigmas, and sigma-like oxeas) occur in the alcoholic specimen at the surface in spots. They are in such places abundant enough to be deceptive, making the impression of being intrinsic elements of the skeleton.

Holotype.—Cat. No. 21341, U.S.N.M.

Suborder LITHISTIDA

Lithistida O. SCHMIDT, 1870, p. 21.

The characteristic megascleres are desmas, generally united into a coherent framework.

The current internal classification of the *Lithistida* which we owe to Sollas (1888) and which with minor changes is employed in Lendenfield's synopsis (1903) is open to some criticism, as Dendy, 1905 (pp. 99, 102), and Hentschel (1912, pp. 305–06) have pointed out. It remains, however, very usable, although if the subdivisions *Hoplophora* and *Anoplia* continue to be employed the *Anoplia* must be extended to include forms with microscleres (see below. *Taprobane*).

Family THEONELLIDAE.

Tetracladidae SOLLAS, 1888, p. 284.
Theonellidae LENDENFELD, 1903, p. 126.

With special ectosomal megascleres, having the character of triaenes (phyllotriaenes, discotriaenes, dicho- or trichotriaenes). The desma is tetracrepid or rarely tricrepid. With microscleres.

Lendenfeld, 1903, changes the name (Zittel's) of the family as used by Sollas; adds *Sulcastrella* O. Schmidt, in which the desma is apparently tricrepid; and merges the following genera: *Neosiphonia* Sollas into *Jereopsis* O. Schmidt, *Rimella* O. Schmidt into *Racodiscula* Zittel, *Collinella* O. Schmidt into *Discodermia* Bocage.

The following forms not included in, or described later than, Lendenfeld's synopsis (1903) fall in this family: *Theonella levior* Lendenfeld (1906, p. 344), *T. lacerata* Lendenfeld (1906, p. 347), *T. annulata* Lendenfeld (1906, p. 350), *T. discifera* (1906, p. 351), *T. pulchrifolia* Dendy (1921*b*, p. 5); *Discodermia natalensis* Kirkpatrick (1902*b*, p. 172), *D. emarginata* Dendy (1905, p. 99), *D. ramifera* Topsent (1904, p. 57), *D. tuberosa* Dendy (1921*b*, p. 6); *Racodiscula clava* (Schmidt) (Topsent, 1904, p. 58).

Genus THEONELLA Gray (1868).

Theonella GRAY, 1868*b*, p. 438.—SOLLAS, 1888, p. 284.—THIELE, 1900, p. 50.—LENDENFELD, 1903, p. 126; 1906, p. 344.

With tetracrepid desmas: with phyllotriaene ectosomal spicules, clads simple or dichotomous or more complexly branched, these spicules grading over in some species to the dichotriaene form; with microrhabds that are usually strongylate but sometimes oxeate.

Thiele, 1900, discusses Sollas' definition of the genus, and would not limit it to cup or vase shaped forms, nor to those with the pores in sieves, but would leave only the skeletal characters as diagnostic. Lendenfeld 1903 adopts this change.

Lendenfeld, 1906 (pp. 343–44), makes a change in the customary distinction between *Theonella* and *Discodermia*, owing to his discovery of a form (*T. discifera*, 1906, p. 351), in which characters hitherto regarded as differentials—namely, phyllo- or discotriaenes—intergrade. This is a good case of the familiar phenomenon that genera which seem to be natural are found, as the number of known species increases, to intergrade with respect to one or more of the differential characters (Wilson, 1919, 1919*b*). The possession of microxeas, larger than the microscleres (strongylate) proper, would still continue, in Lendenfeld's scheme, to set off *Discodermia* from *Theonella*. But these two classes of spicules intergrade in some species, as for instance, *Discodermia ramifera* Topsent (1904, p. 58), where they form but a single class, the range in length being 20–45 μ. The same holds for *Discodermia emarginata*, var. *lamellaris* of this report. In most of the recorded species of *Discodermia* the difference in size between the microrhabds and the microxeas is not very great, the former ranging about 10–20 μ, the latter up to 50 μ, in length. In a few species, however, the categories are quite distinct, as in *D. panoplia* Sollas, where the microxeas have a length of 70–100 μ, the microrhabds a length of only 10–15 μ.

THEONELLA SWINHOEI Gray.

Theonella swinhoei Gray, 1868*b*, p. 565.—Sollas, 1888, p. 284.—Lendenfeld, 1903, p. 126.

Four specimens, two from station D5218, one from D5593, and one from D5252, cannot be separated from one another nor from Gray's species. They show however that the species idea must be somewhat modified. Thus the ridges and projecting lobes which are conspicuous on the surface of some specimens (Sollas, 1888, Lendenfeld, 1903) may be absent in others. The vasiform habit with single cylindrical cloaca extending nearly through the entire sponge, again, is not constant. For the cloaca may extend only through the upper half of the sponge, or instead of being vasiform the sponge may be massive, the upper surface bearing several oscula, each leading into a cloacal canal which extends through one-quarter to one-third the total height of the sponge. The pores are not strictly in groups (sieves, Sollas), but the whole dermal membrane is uniformly porous. The system of larger subdermal cavities which may be joined "together to form irregular sinuous canals, having a somewhat stellate arrangement," which are "seen as dark spaces through the skin" (Sollas, 1888), is not constant. The species remains characterized especially by the skeletal elements, in particular by the phyllotriaenes. These spicules are arranged in several layers in the ectosome; the rhabdome is short; the clads long and narrow with irregular outline, very variable in the same specimen, and indeed in the same spicule, sometimes simple, sometimes irregularly bifurcate or even trifurcate—that is, with secondary branches that divide.

One of the specimens from D5218 is about cylindrical, tapering toward the upper end, passing below into an expanded amorphous basal part; 65 mm. high, 35 mm. in transverse diameter. An osculum, 6 mm. in diameter, at the upper end passes into a cylindrical cloaca which extends down nearly to the base of the sponge. The second specimen, 80 mm. high with transverse diameter of 50 mm., from this locality is very similar. The base of this specimen has been torn off. The osculum measures 10 mm., the cloaca 15 mm., in cross diameter. Color of these sponges, a light brown.

The sponge from D5593 is 90 mm. in height, with a transverse diameter of 50 mm. in the upper half, widening below; vase-like; osculum 15 mm. in diameter; cloaca 18 mm. in diameter, tapering below, 45 mm. deep. The apertures of the very numerous canals opening into it are not all open, some being closed in with sieve-membranes.

The specimen from D5252 is not vasiform, but massive; somewhat elongated vertically, larger above, smaller below near the basal surface by which sponge was attached; height 95 mm., horizontal diameter 80 mm. above, 50 mm. below. The somewhat flattened upper surface bears four oscula, 8–10 mm. in diameter, each leading into a cloacal canal of about the same width and 20–30 mm. deep.

In none of these specimens does the surface bear marked ridges or protuberances.

The pores are strictly not in groups, although they may appear so. The fact is that the dermal membrane, riddled everywhere with pores, rests immediately on narrow subdermal trabeculae about 60 mm. thick, which include the clads of the phyllotriaenes and which surround and inclose small subdermal chambers, 150–230 μ in diameter. Into each of these chambers a few, 1–5, pores open. Balsam preparations show that, as is so often the case in sponges, there are pores directly over the subdermal trabeculae as well as between them, the trabeculae only *appearing* to be solid.

The larger subdermal spaces, other than the small uniformly distributed ones just referred to, as seen through the dermal membrane, vary in appearance in the different specimens. In those from D5218 they are inconspicuous and rounded. In that from D5593 they are conspicuous, narrow, sinuous canals, about 1 mm. wide, and about 10 mm. apart, which anastomose to form a coarse network. In the specimen from D5252 these spaces for the most part are rounded and separate, but there are also narrow, subdermal, tangential channels as in the sponge from 5593. The various appearances, including that of Sollas' specimens (Sollas, 1888, p. 285), seem to be due to the degree in which conspicuous tangential canals are developed interconnecting the subdermal mouths of the canals which penetrate the interior.

In details of surface appearance, including the color, which is lighter, the specimens from D5252 and D5593 resemble one another more than they do those from D5218 and, as will be seen below, this is true also for the microstrongyles.

The skeletal measurements are close to or within those recorded by Lendenfeld for the species. In the desma the clads are 30–40 μ thick, 200–250 μ long if simple, but sometimes bifurcating. Zygosis terminal.

In the phyllotriaene the rhabdome, 80–130 μ long, 12–20 μ thick, tapers to a point, sometimes strongylate. Clads, if simple, 200–300 μ long, commonly 12–16 μ wide (width varies from 8 to 20 μ). In a selected characteristic bifurcate clad, primary branch (protoclad) was 70 μ long, secondary (deuteroclad) 200 μ long. In another the protoclad was 105 μ long, the deuteroclads 110 and 50 μ long. The spicules, as said, are very variable.

Skeletal rhabds, strongylate or very slightly tylote at the ends, 400–500 by 8 μ, in bundles, some of them radial to the surface, and scattered through the interior. Very abundant in the neighborhood of the osculum, beyond the limits of the desmas.

Microstrongyles in the specimens from D5218, 20–24 by 3 μ; in those from D5593 and D5252, smaller, only 12 by 2–3 μ; in all, curved or bent as usual, the surface roughened in a feebly spinose fashion. The range for the previously recorded specimens is 15–30 by 2–3.9 μ (Lendenfeld, 1903).

The species has been recorded from the neighborhood of Ternate, Celebes, Amboina, Manila, and Formosa.

THEONELLA SWINHOEI Gray, var. VERRUCOSA, new variety.

Plate 43, fig. 1; plate 49, fig. 10.

One (dried) specimen from D5356.

The sponge here recorded differs from the type in two features, precise enough for use in classification. The epactines of the desmas are not smooth as in the type, but verrucose with low conical tubercles; and the microstrongyles of the surface are smaller than those of the interior.

Body vasiform, subspheroidal, somewhat obconical, higher than wide (120 mm. high, 110 mm. across the upper surface). Base flattened. Surface with low irregular bosses. Cloaca extending through the body, its aperture on upper surface of sponge 35 mm. wide. Color varies from gray to brown.

The epactines of the desmas may be simple or bifurcated or may end in flattened extremities, as Sollas has pointed out (1888, p. 285). They are in general distinctly verrucose, sometimes strongly so, sometimes weakly so, and sometimes smooth. The low blunt conical tubercles, sometimes arranged in rings, cover the shaft, and are distinct from the complex tubercles developed in the region of zygosis. In general the zygosis is terminal, as described by Sollas, the skeletal reticulum showing nodal enlargements. But sometimes the tuberculate enlargement extends from the node along the whole side of a skeletal mesh. The union in such a case is no doubt lateral as described by Thiele (1900, p. 53), and as I have been able to observe myself in some instances. The epactines are thicker than in the type, their thickness ranging from 40 to 70 µ. The skeletal meshes vary from 130 by 80 µ to 250 by 250 µ.

The phyllotriaenes (pl. 49, fig. 10) are larger than in the type. The clads are bifurcate or, not rarely, trifurcate. Width of protoclad 24–40 µ, length of protoclad and deuteroclad together commonly about 350 µ. Rhabdome about 100 by 30–40 µ. The phyllotriaenes form a single layer, not several as in the type.

The skeletal strongyles, 500 by 7–8 µ, lie chiefly in small radial bundles between the subdermal cavities, along with the outermost radially directed beams of the skeletal framework.

The microstrongyles are abundant in the interior and in the dermal membrane. In the interior the spicules measure 10–22 by 2–3 µ, the larger sizes the common ones. The spicules are roughened in the usual way, and the larger ones commonly curved or bent in the middle. In the dermal membrane, with a few exceptions here and there, they measure only 10–12 by 2–3 µ, and are straight or nearly so.

Holotype.—Cat. No. 21342, U.S.N.M.

THEONELLA INVAGINATA, new species.

Plate 43, fig. 2; plate 49, figs. 11, 12, 13, 14, 15.

One specimen from station D5335.

Sponge vasiform, tapering below to the attached base; 35 mm. high, 20 mm. across at the upper end. A terminal osculum, 2 mm. wide, leads into a long narrow cloaca having a maximum width of

5 mm., which extends to the lower end of the sponge. The cloaca opens to the exterior not only at the terminal osculum, but by means of lateral diverticula at three other oscula as well. Two of these are near the upper end, one near the lower. All the oscula (pseudoscula, as they would more properly be called) are of about the same size. Sponge stony; pinkish-brown.

Pores in the rounded meshes of a skeletal reticulum that is formed by the overlapping clads of the ectosomal phyllotriaenes. Meshes of the reticulum 150–200 μ in diameter; two or three pores, sometimes only one pore, in each mesh.

The tetracrepid desma (pl. 49, figs. 11, 15) starts out as a triaene. The four primary clads, which become more or less branched, make bold curves, bounding different skeletal meshes. They become tuberculate at the ends where they enter into zygosis. The primary clads frequently but not always bifurcate, and the secondary branches again may send out short branches; all branches tuberculate at the ends, zygosis being terminal. Primary clads about 35 μ thick. Length of undivided clad 100–175 μ. In a bifurcated clad, primary branch 75–125 μ long, secondary branches 50–140 μ long.

The dermal phyllotriaenes (pl. 49, fig. 12) form a single layer. Rhabdome is about 150 by 20 μ, tapering to a point. Typically there are three narrow primary clads which branch irregularly, the spicules being, thus, not far removed from the dichotriaene type. There is considerable variation, however, as regards details. One of the primary clads may not branch, while the others do. Or a primary clad may simply widen out into an irregular termination instead of branching. The secondary clads often do not branch, or some branch and others do not. Occasionally there may apear to be four main clads, but this is probably due to bifurcation of one of the three primary clads close to the center. Length of clads variable; primary clads commonly 100–200 μ long, 35 μ wide; secondary clads commonly 75–150 μ long.

The membrane lining the cloaca includes phyllotriaenes, which may be designated gastral phyllotriaenes, arranged in a single layer with rhadomes vertical to the surface. They (pl. 49, figs. 13, 14) are of a different type from those of the dermal surface, varying toward the discotriaene form. Rhabdome 60–90 by 12–14 μ. The cladomes which overlap in an irregular way are greatly flattened and very thin. They vary from that of an ordinary phyllotriaene with dichotomous clads to an irregular platelike cladome in which clads are not distinguishable. Often three primary clads are present in the shape of stout wide lobes which expand terminally but are not subdivided. Or the unexpanded end of the lobelike clad may be subdivided by a shallow notch into two secondary lobes. Greatest diameter of cladome 180–450 μ.

Long slender smooth rhabds occur in the ectosome of the dermal and gastral surfaces. In the dermal ectosome they form radial bundles, and are also scattered singly. In the gastral ectosome they form both radial and tangential bundles. The spicules, which are difficult to isolate whole, reach a length of 420 μ and are 4–6 μ thick. They include strongyles with slightly tylote ends and styles which taper evenly to a point and are placed with the rounded end outermost.

Microrhabds form a crust at the dermal and gastral surfaces, and are abundant in the interior. They measure 8–12 μ in length, 2 μ thick; surface prickly; ends strongylate or oxeate.

Holotype.—Cat. No. 21304, U.S.N.M.

From the fact that in this sponge the cloacal membrane includes phyllotriaenes, it is probable that the cloaca is to be looked on as having a different morphological value—that is, as having arisen phylogenetically in a different way, and probably as produced ontogenetically in a different way, from the cloaca of other species of *Theonella*, such as *T. swinhoei.* In the latter species the lining membrane of the cloaca (or cloacae) is like that of the canals in general—namely, contains abundant microrhabds but no phyllotriaenes. The cloaca then in such species is probably to be looked on as merely an enlarged canal, or as a space produced by the fusion of canals during ontogenetic growth. In *T. invaginata*, on the contrary, the cloacal lining seems to represent an inturned part of the ectosome—that is, a part which has become virtually inturned through the continued upward growth of the margin of the young sponge.

Analogies to the species here described are presented by *T. discifera* Lendenfeld (1906, p. 351) from the west coast of Australia, and in a less degree by *T. lacerata* Lendenfeld (1906, p. 347) from near Sumatra. In the dermal phyllotriaenes of the latter species the clads are very wide and irregular, sometimes undivided, the cladome thus varying in the direction of the discotriaene (1906, pl. 44, figs. 1, 3). In the former species the dermal triaenes are a mixture of phyllotriaenes, discotriaenes, and intermediate forms (1906, pl. 43, figs. 8–12). The variation in these species toward the discotriaene form, it will be noticed, affects the triaenes of the surface in general, whereas in the *Albatross* species this tendency comes into activity only over the inner (probably in an earlier stage of growth, the upper) face of the sponge.

THEONELLA CYLINDRICA, new species.

Plate 44, fig. 4; plate 50, figs. 1, 2, 3.

One specimen from station D5593.

Sponge irregularly cylindrical, 80 mm. high, 9 to 13 mm. in transverse diameter, bearing several protuberances, and expanded below where it was probably attached. Sponge rigid; yellowish brown in color.

The dermal membrane exhibits the usual closely set, more or less rounded, pore areas separated by the dermal skeletal reticulum made up of overlapping clads of the phyllotriaenes. The pore areas are about 150–200 μ in diameter, each including 3–6 pores. Only a single osculum is to be seen, slightly less than 2 mm. in diameter, leading into a small cloacal canal; this is on the side of the sponge, upon one of the protuberances. Sponge interior contains only fine canals, 0.5 mm. and less in diameter. There are numerous small subdermal cavities.

The ectosomal phyllotriaenes (pl. 50, fig. 1, *a*, *b*) form a single layer. Rhabdome short, sharp pointed or rounded at the apex; usually a little irregular; about 100 by 22 μ. Clads variable and irregular; flattened and narrow; bifurcated or not; but typically some, though not all, the clads of a spicule are bifurcated; greatest length of an entire clad about 250 μ, width 28–30 μ. Clads closely interlaced to form a firm dermal skeletal reticulum.

The clads of the tetracrepid desmas (pl. 50, figs. 2, 3) are smooth except at the ends, where zygosis takes place. Here they break up into a few, short branches bearing irregular tubercles. Clads 140–175 μ long, about 35 μ thick.

The skeletal rhabds are long and slender, about 600 by 5 μ; strongylate at the outer end, strongylate or tapering to a point at the inner end; chiefly in bundles that are more or less radial to the surface, but there are some scattered spicules.

The microrhabds are very small, 8 by 3 μ; rounded at the ends and roughened with minute prickles; abundant in dermal membrane and interior.

Holotype.—Cat. No. 21305, U.S.N.M.

In respect to habitus, the sponge approaches closest to *Theonella conica* (Kieschnick). But in this species (Thiele, 1900, p. 50) the clads of the phyllotriaenes are not branched, and the skeletal framework is feeble, the desmas being easily isolated. Except for the habitus and the unusually small size of the microrhabds the sponge would not be separable from *T. swinhoei.*

Genus DISCODERMIA Bocage (1869).

Discodermia Bocage, 1869, p. 160.—Sollas, 1888, p. 292.—Thiele, 1900, p. 51.—Lendenfeld, 1903, p. 128.—Dendy, 1905, p. 99.—Lendenfeld, 1906, p. 353.

With tetracrepid desmas; ectosomal megascleres are discotriaenes; microscleres are strongylate microrhabds and larger microxeas, which in some species intergrade forming but one class of spicule.

Some reference to the facts underlying the separation of *Discodermia* from *Theonella* has already been made under *Theonella*. It is evident that the two genera can not be sharply separated, either on the score of the discotriaenes or on the possession of microxeas. Nevertheless, while the two groups of species intergrade, it seems advisable to retain, at least for the present, both genera.

DISCODERMIA EMARGINATA Dendy.

Discodermia emarginata Dendy, 1905, p. 99.

A single specimen from station D5414, agreeing closely with Dendy's type, from the Gulf of Manaar, in respect to habitus and skeleton.

The sponge is an amorphous mass about 40 mm. in diameter, showing low rounded protuberances. It is attached to another sponge, *Petrosia crustata*. The consistency is dense and stony. No oscula were discoverable with certainty. Doubtless they are small apertures, more or less closed, as in the specimen of var. *lamellaris* (see below), and so scattered as to escape observation. The pores 30–50 μ in diameter, are scattered over the surface, in the gaps in the dermal armor formed by the overlapping disk-like cladomes of the triaenes. They occur singly; or in groups of two or three, or sometimes in curving rows which include a number (up to about six) of pores. They open for the most part into small rounded subdermal spaces which are independent of one another, each connecting with the exterior by one or a few pores.

The desmas are similar both in adult and developmental stages to those described by Dendy.

The discotriaenes are like those of the type. Diameters of the cladome range commonly from 180 to 250 μ. The spines on the outer face are low and conical, disappearing near the margin of the disk. The rhabdome, 80–150 μ long by 20–30 μ thick, is pointed or rounded at the apex.

The long slender rhabds are common. They are sometimes, I think always, oxeate at both ends; 5 to 8 μ thick, and in the neighborhood of 1 mm. long. They occur in loose bundles, oblique or radial to the surface, in the peripheral part of the sponge and seem to be especially abundant at the apices of the rounded protuberances.

In Dendy's type no microxeas are mentioned. The microrhabds are described as "usually fusiform and strongylate, with very minutely roughened surface"; 16 µ long. In the *Albatross* specimen the microrhabds are similar, the ends strongylate to oxeate but never sharp; 12–18 µ long by 2–3 µ thick at the middle. They form a thin layer, one spicule thick, external to the triaene cladomes; are especially abundant round the pores, and common in the walls of the canals and throughout the interior.

Using Lendenfeld's definitions of Theonellid genera (1903), the sponge falls in *Kaliapsis*. But the spinose character of the outer face of the disk in the triaene, on which Lendenfeld lays emphasis, does not seem to be a sufficient reason for separating such species from *Discodermia*.

DISCODERMIA EMARGINATA Dendy, var. LAMELLARIS, new variety.

Plate 43, fig 5.

Under this heading I record two specimens from station D5482 of lamellate habitus, one face bearing the oscula, the other the pores, as in some other species of the genus (*D. discifurca* Sollas, *D. ornata* Sollas). The skeletal and other differences from the type are slight, and it is not improbable that the variety merely represents an older stage of growth, the type a younger one.

In the specimen illustrated the base is amorphous, from which the body rises in the shape of an irregular lamella about 5 mm. thick. This is curved, showing a concave and a convex surface. The concave surface bears the oscula which are just visible to the eye; the opposite surface bears the pores. The greatest diameter of the whole mass is 50 mm.

In the other specimen, the body rises from a flattened base as a curved lamella similar to the preceding. But several lamellate outgrowths seem here to have fused with one another in an irregular way, so as to surround and imperfectly roof in a space. Greatest diameter of the whole mass 65 mm.

The oscula are abundant, 250 µ to 1 mm. apart. Most are closed by the usual thin membranes, but the cylindrical oscular canals leading radially inward are conspicuous. The osculum, when fully open, probably has about the diameter of the oscular canal, which ranges from 80 to 195 µ, exceptionally reaching 250 µ.

The arrangement of pores is interesting. They are much more numerous than in the specimen assigned to the type, but of about the same size. They are closely set in rows, one pore wide. The rows of pores interconnect with one another and thus give rise to an irregular reticulum. In each mesh of the reticulum there is sometimes only one, more often a number (two to four), of the discotriaene cladomes.

In correlation with the increase in the number of pores, the subdermal cavities, which in the specimen assigned to the type had already begun to fuse in rows, here constitute tubular channels, about 250 μ wide, which extend parallel to and just beneath the surface membrane. Such channels have obviously been produced by the continued formation of small subdermal cavities and their fusion in rows. (They are best seen in thick tangential sections of the surface region, examined from the inner side.)

Again, the main afferent and efferent canals have acquired a certain regularity of arrangement in correlation with the lamellate shape and the differentiation of the two faces as oscular and poriferous. They are of about the same size and they both pass radially into the sponge interior from the respective faces.

As to the skeleton of these lamellate specimens, the long slender rhabds are especially abundant in the marginal region. Otherwise the only skeletal difference from the type concerns the microscleres. These are here less uniform, ranging commonly from 8 to 25 μ in length, 2 to 3 μ thick at the middle; not infrequently reaching a size of 40 by 4 μ. All the spicules are minutely roughened, thicker in the middle and tapering toward the ends; ends strongylate in the smaller spicules, oxeate in the larger but never sharp; in the larger spicules, the two halves commonly bent at a slight angle; the larger spicules sometimes distinctly centrotylote. While the presence in considerable numbers of the very small rhabds, often narrowly ellipsoidal in shape, catches the eye, all sizes and shapes of these spicules are intermingled and intergrade so that they can not be separated: the distribution is the same as in the specimen assigned to the type. Thus as in the case recorded by Topsent, *Discodermia ramifera* (Topsent 1904, p. 58), the microscleres here form a single category which includes both the *microrhabds* and the *microxeas* of the conventional generic diagnosis as given for instance by Sollas (1888) and Lendenfeld (1903, 1906).

Holotype.—Cat. No. 21260, U.S.N.M.

Genus JEREOPSIS O. Schmidt (1879).

Jereopsis O. SCHMIDT, 1879, p. 20.—LENDENFELD, 1903, p. 133.
Neosiphonia SOLLAS, 1888, pp. 299, 334.

The desma is tetracrepid; crepis, in some species at least, an amphitriaene. The ectosomal triaenes are dichotriaenes or trichotriaenes. With streptasters that vary from the spiraster to the amphiaster type.

JEREOPSIS FRUTICOSA, new species.

Plate 43, fig. 3; plate 50, figs. 4, 5, 6, 7, 9, 11, 12.

One specimen from station D5168.

Sponge body a fruticose mass consisting of branches which diverge from the small basal part, anastomosing here and there with one another. Whole mass 55 mm. high, 90 mm. in one horizontal axis, 50 mm. in the other. Branches fundamentally cylindrical, about 7 mm. in diameter; somewhat flattened and lobe-like, especially at the ends. Oscula, 1 mm. in diameter, at the ends, and in rows along the flattened upper side, of the branches; no oscula on under surface of sponge. Sponge hard, stony; brownish yellow.

Spicules.—1. Desma. The desma is built not on a calthrops nor a simple triaene but on an amphitriaene, as is shown by the followering facts. Small free amphitriaenes (pl. 50, fig. 4) about 160 μ long occur sparingly in the ectosome. In these the axial canal extends through the shaft, and to the tip of each clad. In the young desmas (pl. 50, fig. 5), which occur in the ectosome and which are free or only slightly connected with the skeletal framework, the amphitriaene character is still obvious. Comparison with the first stage (pl. 50, fig. 4) shows that the shaft has increased in thickness but not in length. The clads on the other hand have increased greatly in length, although the axial canal extends only into the basal part of the clad. In the adult desma (pl. 50, fig. 9) the axial canal system continues to reveal the original amphitriaene state—that is, it has not changed with the growth of the desma, the canals still extending into the bases of the primary clads. From the end, however, of each branch of the original axial canal system (a system of sharp, distinct lines) there may be traced, after boiling in nitric acid, a pale granular axial streak which extends throughout the branching clad. Comparison with the earlier stages shows that the shaft has continued to increase in thickness but has retained its original length. The clads vary greatly in different spicules and even on the same spicule. The original (primary) clad may remain undivided, or secondary clads may be formed on it, and even tertiary clads on the secondary. There seems to be a law of growth whereby no unbranched clad shall materially exceed the shaft in length. Zygosis is established through the development of abundant bulbous interlocking projections on the ends and sides of the *terminal* clads, whether these be primary, secondary, or tertiary (pl. 50, figs. 7, 12). In the adult desma the shaft is 50–60 μ thick; the meshes of the skeletal framework 90–210 μ in diameter. The peculiar desma of this species and the interpretation of the facts have been discussed in an earlier paper (Wilson 1920).

2. Dichotriaenes. The cladomes (pl. 50, fig. 11) lie in the dermal membrane; primary clad 30–35 by 17–21 μ, secondary clads 100–130 μ long. Rhabdome 105–125 by 14–21 μ, pointed at the end, sometimes bluntly. Spicules are common in which one or a few of the terminal clads are not of full size, sometimes slightly deformed. The trichotriaene variation, found in *Jereopsis superstes* (Sollas), was not observed.

3. Oxeas. Small oxeas, 100–180 by 4–5 μ, occur alongside the rhabdomes of the triaenes, projecting slightly from the surface. Larger oxeas, about 240 by 5 μ, occur in the ectosome apart from the triaenes, but radial to the surface, singly or in bundles of a few. These and the small forms are fairly abundant round the oscule.

A few large oxeas, possibly foreign, were observed; they measured 400–600 by 16–24 μ, with blunt ends.

4. Streptasters. The spicules of the interior are amphiasters (pl. 50, fig. 6, *a*) or amphiasters that approach the spiraster type (fig. 6, *b*). In the former, the total length of which is about 24 μ, there are about four long, slender rays at each end of the short slender axis. In the latter class of amphiaster the total length is about 20 μ, the axis is stouter, and the rays somewhat shorter, stouter, more numerous and more distributed along the axis.

The streptasters of the dermal membrane (pl. 50, fig. 6, *c*) are spirasters about 16 μ long. Rays shorter and blunter and more numerous than in the spicules of the interior, and scarcely or not at all grouped at the ends of the axis. All classes of streptaster are minutely roughened.

Holotype.—Cat. No. 21271, U.S.N.M.

Family COSCINOSPONGIIDAE.

Corallistidae Sollas, 1888, p. 301.
Coscinospongiidae Lendenfeld, 1903, p. 135.

With ectosomal triaenes which may be dichotriaenes, phyllotriaenes, or discotriaenes. Desma monocrepid and tuberculate.

Lendenfeld accepts the family in Sollas' sense but restores Coscinospongia Bowerbank, not recognized by Sollas, into which he merges two of the genera used by Sollas, *Corallistes* and *Heterophymia*, thus making it necessary to change the family name. By other mergings Lendenfeld still further reduces the number of genera employed by Sollas.

In this family there have been described since Lendenfeld's synopsis (1903) *Coscinospongia gracilis* Lendenfeld (1906, p. 354), *Macandrewia auris* Lendenfeld (1906, p. 358), *M. robusta* Topsent (1904, p. 61), *M. ramosa* Topsent (1904, p. 62).

Genus COSCINOSPONGIA Bowerbank (1869).

Coscinospongia Bowerbank, 1869, pp. 85, 99.—Lendenfeld, 1903, p. 135 (synonomy).

The dermal triaenes are dichotriaenes or derivatives of the same, regarded as mesotriaenes with distal ray but without rhabdome.

COSCINOSPONGIA THOMASI (Sollas).

Plate 50, fig. 10.

Corallistes thomasi Sollas, 1888, p. 307.
Coscinospongia thomasi (Sollas), Lendenfeld, 1903, p. 137.

Station D5513, two specimens: lamellate, ascending in the water, attached below, the free margin rounded. One measures 75 mm. wide, 60 mm. high, about 4 mm. thick. The other is somewhat smaller and broken. Color, light brown. Both sponges considerably larger than Sollas' specimen.

The sponges show there is no constant relation between convexity and concavity of surface and the distribution of pores and oscula. For in one specimen the pores are on the more convex side, oscula on the more concave, while the opposite is true of the other specimen. The pore areas are small circular depressions about 200 μ in diameter and 0.5 mm. apart. In the center of the area, in a few cases, a minute aperture, the pore, has remained open. The very similar oscular areas on the other side are somewhat larger, about 300 μ in diameter and 1–2 mm. apart. Again, in a few cases, a minute aperture, the osculum, has remained open in the center of the area.

The spicule measurements are close to those given by Sollas (1888).

The desma (pl. 50, fig. 10) shows the characteristic fungiform tubercles, some of the tubercles on the most peripheral desmas supporting the dermal membrane along with the cladomes of the triaenes. The length of a developed desma is 400–500 μ, thickness of middle body, epirhabd, 30–35 μ. There are several clads, reaching 175 μ in length, and the spicules present bold curves which help to bound different skeletal meshes. The tubercles are for the most part simple, or there are two or three closely juxtaposed tubercles on the same stalk, or the tubercle may be indented as if subdividing. Range in width of tubercle 24–50 μ.

In the dichotriaene, the rhabdome measures 210–280 by 28–35 μ; primary clad 28–35 μ long and about as wide; secondary clads 65–100 μ long, not always alike in same spicule, sometimes irregularly curved. Margins and upper surface of clads uneven, about as in Sollas' specimens.

Very slender rhabd spicules occur on the pore side of the sponge. They lie in the ectosome, radial to the surface and projecting beyond it; fairly abundant, but distributed singly at distinct intervals. The spicules are oxeas, 300–350 by 1–2 µ. They doubtless correspond to the orthotrichites observed by Sollas (1888, p. 307) in boiled out preparations.

The dermal crust formed by the microstrongyles is one layer deep. The spicules have the characteristic wavy (angularly serpentine) shape and measure 24–32 by 4–5 µ.

The streptasters are 20–24 µ long; axis short, slightly curved, sometimes appearing to be straight; the rays, tapering and sharp-pointed, commonly both on the axis and at the ends. The spicule varies, as in Sollas' specimen, from forms with shorter and more numerous rays to those with longer and fewer, frequently 5–8, rays. The amphiaster shape, with about 3 rays at each end, is sometimes assumed.

Family PLEROMIDAE.

Pleromidae SOLLAS, 1888, p. 312.
Pleromatidae LENDENFELD, 1903, p. 140.

With special ectosomal megascleres having the form of triaenes. Desma monocrepid and not tuberculate, sometimes of a simple rod-like character.

COSTIFER, new genus.

Desmas typically rodlike, without clads; loosely articulated together. Other megascleres are ectosomal plagiotriaenes, large oxeas radial to the surface, and small parenchymal oxeas. Microscleres, streptasters and microrhabds.

COSTIFER VASIFORMIS, new species.

Plate 43, fig. 6; plate 50, figs. 8, 13, 14; plate 51, fig. 1.

Station D5168, one specimen, dried.

A vase-shaped sponge 270 mm. high; transverse diameters of upper end, 280 mm. and 210 mm.; base flattened and about 150 mm. wide. The cloacal cavity extends throughout the sponge and is, no doubt accidentally, open below. Wall of vase 20–25 mm. thick in the upper part of sponge, thicker below. Sponge heavy, firm and incompressible, but scarcely stony. Color, light brown to light gray.

Outer surface of sponge much incrusted with foreign matter. Naturally it is covered with a crust of projecting plagiotriaenes. Closely set fine canals, 0.25–0.5 mm. in diameter, extend in from this surface, their apertures more or less covered by the layer of plagiotriaenes. The surface of the cloacal cavity shows closely set, rounded apertures, 1 mm. and less in diameter; these doubtless are small oscula.

Spicules.—1. Skeletal desma, monocrepid; commonly rodlike without clads and with two concave articular surfaces (pl. 50, fig. 13). Rod somewhat curved or bent; smooth or slightly roughened with a few vague elevations; ends tapering, or rounded and blunt, sometimes gnarled. Rarely desmas occur (pl. 50, fig. 8) in which the epirhabd has developed one or a few clads, the articular facets still remaining on the epirhabd. The desmas are loosely articulated together and fall apart during boiling. They are distributed uniformly throughout the parenchyma. Common length of desma, 2.0–2.5 mm., diameter 110–170 μ.

2. Large oxeas (pl. 50, fig. 14 *a*), 2–2.5 mm. long, about 70 μ thick; arranged more or less vertically to the dermal membrane at both surfaces.

3. Plagiotriaenes (pl. 50, fig. 14, *b*), abundant at both surfaces. Rhabdome about 850 μ long, 45 μ thick; clads 400 μ long. Numerous smaller sizes present. The spicules sometimes, rarely, assume partially or completely the dichotriaene character in that one or more rays fork.

At the outer surface the spicules form an exposed crust or armor outside the dermal membrane. In this extradermal crust the cladomes are paratangential to the surface of the sponge, the rhabdomes radial, the spicules forming several layers. The spicules evidently emerge from the sponge body at slight elevations of the actual dermal surface; from such elevations numerous spicules may be seen protruding, the rhabdomes diverging somewhat from one another. Plagiotriaenes quite like the extradermal ones lie also in the ectosome, the cladomes supporting the dermal membrane, the rhabdomes radial.

At the inner surface a thick extradermal crust of plagiotriaenes is not present, although a considerable number of spicules project through the dermal membrane, the cladomes becoming extradermal. Cladomes of other spicules are in the ectosome and support the dermal membrane, the rhabdomes radial.

4. Small oxeas (pl. 51, fig. 1, *a*), so-called microxeas, very abundant in the parenchyma; smooth and evenly tapering, 90–165 μ by 4 μ.

5. Microrhabds (pl. 51, fig. 1, *b*), in the form of microstrongyles about 20 by 5 μ, exceedingly abundant in the dermal membrane at both surfaces. Outline of spicule irregular, the irregularities sometimes sufficiently pronounced to deserve the name of protuberances.

6. Streptasters (pl. 51, fig. 1, *c*), with very short axis and rays that are often vaguely grouped at the two ends of the spicule; abundant in the parenchyma. Total length of spicule about 15 μ, ray length 5–7 μ.

Holotype.—Cat. No. 21343, U.S.N.M.

The nearest relative of this remarkable sponge seems to be the equally remarkable little form, *Pleroma turbinatum*, dredged by the *Challenger* off one of the Fiji Islands and described by Sollas (1888, p. 312) as the representative of a new family, the Pleromidae. The simple character of the desma, the shape of which often suggests a rib, is noteworthy in *Costifer*. The spicule resembles the rodlike young stage of monocrepid desmas in general, more especially in such a species as *Scleritoderma paccardi* O. Schmidt (1879, pp. 9, 28, pl. 2, fig. 3).

Family SCLERITODERMIDAE.

Scleritodermidae Sollas, 1888, p. 315.
Scleritodermatidae Lendenfeld, 1903, p. 141.

With special ectosomal megascleres having the character of rhabds (tylostyles, styles, tylostrongyles, strongyles). Desma is monocrepid. Microscleres when present are sigmas.

Lendenfeld (1903, p. 141) accepts Sollas' family comprising the two genera *Scleritoderma* O. Schmidt and *Aciculites* O. Schmidt. Sollas' designation of the rhabds as microstrongyles is properly abandoned but Lendenfeld's reference to them as amphistrongyles is not apt.

Assignable to the family and described since Lendenfeld's synopsis (1903) is *Aciculites orientalis* Dendy (1905, p. 101) from Ceylon. Regarding *Microscleroderma* Kirkpatrick and *Taprobane* Dendy, see appendix to Leiodermatiidae.

Genus ACICULITES O. Schmidt (1879).

Aciculites O. Schmidt, 1879, p. 29.—Lendenfeld, 1903, p. 143.—Dendy, 1905, p. 101.

Scleritodermidae without microscleres.

Dendy (1905, p. 101) would place the genus in the Leiodermatiidae.

ACICULITES CILIATA, new species.

Plate 43, fig. 7; plate 51, figs. 2, 3.

Station D5356, one specimen. The sponge is a thick walled stony cup more or less conical in shape but asymmetrical. Greatest horizontal diameter 53mm., height 35mm., wall about 10mm. thick. Latero-inferior surface separated from surface of cavity by a nearly flat margin, 10mm. wide, which faces upward and outward. Color of surface, brown; interior, lighter. In the marginal region of the cup numerous small canals, a fraction of a millimeter wide, lying just below and parallel to the dermal membrane, may be seen radiating toward the cavity of the cup. In the substance of the sponge small canals, about 0.5 mm. wide, are numerous. The ectosome of the sponge appears to be perfect over the marginal region but is only partially preserved over the outer surface and has disappeared from the surface of the cavity.

Desma monocrepid, more or less curved and branched and with abundant tubercles; greatest length commonly about 350 µ, thickness of middle body 30 µ. Some tubercles are simple, but the characteristic ones are compound, resembling irregular rosettes. The desmas are firmly united; skeletal meshes rounded and frequently about 100 µ wide. In the ectosome abundant developing desmas are present (pl. 51, fig. 2). The smallest observed were slightly irregular rods (fig. 2, *a*). These become branched through the development of outgrowths (fig. 2, *b*). The outgrowths (clads) become fairly long and the desma thus acquires several bold curves (pl. 51, fig. 2, *c*; pl. 51, fig. 3), which help to bound different skeletal meshes. But straighter, more elongated, forms also occur.

The special ectosomal megascleres in the marginal region of the sponge are tylostyles or styles, 385–540 by 8–10 µ, head end terminally spinulate, tapering gradually toward the point which is blunt, the spicule sometimes slightly curved. In the tylostyle form the head end is only slightly enlarged. Some of the spicules lie tangentially at the surface forming a thin crust, one layer deep. Others are radial to the surface, distributed singly but at short intervals; the spicules not projecting or scarcely projecting beyond the surface; outer end of the spicule is the basal, larger, end.

Over the outer surface of the sponge dermal megascleres, such as have just been described, are not found. In their stead are long and very slender oxeas, 350–700 by 2–3 µ; tapering gradually toward both ends, which are sharp; spicule often slightly curved. Some lie tangentially at the surface, but most are radial. The latter are not in bunches, but distributed singly at short intervals; they penetrate well into the interior and project for the most part 300–400 µ beyond the surface, looking something like long cilia. Dermal spicules of the inner surface of sponge unknown.

Holotype.—Cat. No. 21251, U.S.N.M.

The species is evidently close to *A. higginsia* O. Schmidt, from off Havana. In this sponge (Sollas, 1888, p. 347) the desma is tuberculate; the rhabd measures 271–355 by 10 µ and is a tylostrongyle, or tylostyle, or strongyle. The rhabds lie tangentially at the surface and form a single layer; are also at right angles to the surface, the tylote end outward and in contact with the dermal membrane. The genus includes, besides the two forms just mentioned, *A. orientalis* Dendy (1905, p. 101) from Ceylon.

Family LEIODERMATIIDAE.

Azoricidae Sollas, 1888, p. 319.
Leiodermatiidae Lendenfeld, 1903, p. 145.

Without special ectosomal megascleres and, except in a few forms, without microscleres. With monocrepid desmas and rhabds.

The family definition is slightly modified, in order to cover *Taprobane* Dendy and *Microscleroderma* Kirkpatrick, for which it seems desirable to create an *appendix*. Of the nine genera recognized by Sollas as belonging in this family Lendenfeld retains only two. Five of the genera including *Azorica* Carter are merged, along with *Petromica* Topsent, in *Leiodermatium* O. Schmidt, and the family name changed. Lendenfeld's synopsis is so convenient that I prefer to follow him in merging *Azorica* in *Leiodermatium*, although the pores and oscula in *Leiodermatium lynceus* (the type of Schmidt's genus: see discussion in Sollas 1888, p. 348) O. Schmidt (1870, p. 22) differ conspicuously from those of Azorica.

Lithobactrum Kirkpatrick (1902*b*, p. 175) falls in and is assigned by its author to this family. If we adopt Lendenfeld's rearrangement of the genera, the genus fits in *Gastrophanella* O. Schmidt. Since Lendenfeld's synopsis there have been reports concerning the following species: *Petromica grimaldii* Topsent, 1904 (p. 64); *P. massalis*, new species, Dendy, 1905 (p. 104), 1921*b* (p. 8); *Leiodermatium pfeifferae* (Carter), Topsent, 1904 (p. 63); *L. deciduum* (O. Schmidt), Lendenfeld 1906 (p. 363); *L. crassiusculum* (Sollas), Hentschel 1912 (p. 307); *Microscleroderma hirsutum*, new genus, new species, Kirkpatrick, 1902*b* (p. 173); *Taprobane herdmani*, new species, Dendy, 1905 (p. 102), 1921*b* (p. 7).

Genus LEIODERMATIUM O. Schmidt (1870, 1879).

Leiodermatium part, O. Schmidt, 1870, p. 22.—As defined by exclusion, O. Schmidt, 1879, p. 28.—Part, Lendenfeld, 1903, p. 145.
Azorica Carter plus *Leiodermatium* O. Schmidt, Sollas, 1888, pp. 319, 352.

Lamellate or vasiform sponges with pores on one face and oscula on the other. The rhabd megascleres are styles or oxeas. Without microscleres.

Possibly one of the species, *L. chonelleides* (Döderlein), assigned to Azorica by Sollas, does not conform to the definition just given. (See Lendenfeld, 1903, p. 147.)

LEIODERMATIUM PFEIFFERAE (Carter).

Plate 43, figs. 4, 8; plate 51, figs. 4, 5, 6, 7.

Azorica pfeifferae Carter, Sollas 1888, p. 319.—Topsent, 1904, p. 63.
Leiodermatium pfeifferae (Carter), Lendenfeld, 1903, p. 148.

Sollas (1888, p. 320) suggests that the *Challenger* specimen from Amboina may represent a piece of a vasiform sponge. A specimen (pl. 43, fig. 4), taken at station D5629, confirms his suspicion that the species may be vasiform as well as plate-like. It is a stony conical cup, 50 mm. high and 70 mm. across the mouth. The wall is smooth and ½ to 2½ mm. thick. The cup is broken open at the base. The apertures of the (presumably) efferent canals, scattered over the inner face, are about 150 μ in diameter; those of the afferent canals, on the outer surface, of about same size.

The desmas are firmly united. The rounded fenestrae perforating the skeleton are smaller, and the skeleton is denser, in the superficial region than in the interior, where the fenestrae measure 70–175 μ in diameter. What may be called a typical desma has a total length of about 340 μ; thickness of epirhabd 35 μ. But the desma varies a good deal both in size and shape. (See Sollas, 1888, p. 323.) The epirhabd may be nearly straight or very curved. The clads, few in number, project at about right angles to the adjoining part of the epirhabd, and may be short or comparatively long. The articular surfaces are at the ends of the clads and epirhabd. They are concave and frequently much expanded (pl. 51, fig. 7, where the concave face of the articular process (*a. p.*) is applied to the other desma) but the articulation is sometimes only one of apposition (pl. 51, fig. 5.) Perhaps the latter condition indicates an earlier stage of zygosis.

The spinose tubercles on the desma vary in shape and frequency. They may be simple spines, or bifurcated and thus bidentate (pl. 51, figs. 4, 7). Very frequently the bifurcation, more strictly speaking the formation of new outgrowths simulating division, is continued (pl. 51, fig. 7), and we eventually get the characteristic tubercles of the species, which consist of an irregular rosette of 3 to 6 or 7 spines surrounding a convex area (pl. 51, figs. 4, 6). The spinose tubercles occur on epirhabd and clads, often abundantly, yet many desmas are comparatively smooth. At the surface of the sponge, the tubercles are small and simple, thickly crowded, often blunt, terminating as described by Sollas (1888, p. 320) at about the same level and thus giving support to the dermal membrane. The rosette-like tubercles described above are identical with those figured by Topsent (1904, pl. 8, fig. 7).

The oxeas which project in small bundles over both surfaces are 350–420 μ long and about 6 μ thick. They are thus smaller than in the Amboina specimen described by Sollas, in which they measured 750 by 8 μ. The oxeas measured by Topsent (1904, p. 64) in a specimen from the Azores reached a length of 700 μ with a thickness of only 1.5 to 3 μ.

The species has been recorded for widely separated parts of the Atlantic, and for the Banda Sea. (See Lendenfeld, 1903.)

A second dried specimen (pl. 43, fig. 8), precise locality unknown, is of the lamellate type. The skeleton shows a radial striation, absent in the other and which is not mentioned in the literature of the species. It is in all probability correlated with the arrangement of the larger canals, neither feature being fixed (hereditary). In order to call attention to this, physiological, peculiarity, the sponge may be designated forma *striata*.

The lamella is 130 mm. wide, 75–90 mm. high, 1.5 mm. thick; one face slightly concave, the other slightly convex. Concave surface vaguely undulating, the undulations parallel to the free edge. On each surface there are thickly crowded minute apertures, about 150 μ in diameter. The oxeas are smaller than in the other specimen, measuring only 240–300 by 3–4 μ.

The skeleton shows on the surface, especially after boiling for a few minutes in nitric acid, fine lines that radiate from the base of the lamella toward the free margin. This radiate arrangement which is visible to the eye exists throughout the interior, as may be seen in tangential sections. The appearance is directly caused by the fact that along lines which are roughly radial, the desmas lie much closer together and are united in a more complex fashion than in the intervening areas. Except in this feature there seem to be no differences from the skeletal framework of the other specimen.

Holotype.—Cat. No. 21321, U.S.N.M.

Appendix to Leiodermatiidae.—Forms with sigmas.

Microscleroderma Kirkpatrick (1902*b*, p. 173) and *Taprobane* Dendy (1905, p. 102) may conveniently be listed here. *Microscleroderma* is assigned by its author to the Scleritodermidae, although it lacks the ectosomal rhabds of this family. Kirkpatrick would overcome the difficulty by interpreting the rhabds in question as modified and large sigmas. But the rhabds of the Scleritodermidae can scarcely be claimed as microscleres, since they measure 80 to 540 μ in length, and it seems very doubtful whether there is any real resemblance to sigmas. The size, radiate arrangement, and tylote outer end of the spicules in species of *Aciculites* suggest, on the contrary, the thought that they may even be degenerate triaenes. Perhaps observations on the variation of the rhabds, including monstrous forms, might throw light on their phylogeny.

Taprobane, as Dendy (1905) has pointed out, would fall in the Leiodermatiidae (indeed in Leiodermatium) were it not for the presence of sigmas and, on the other hand, might be regarded as a Scleritodermid without special ectosomal spicules, and thus there is no place for it in Sollas' classification. The general evidence that microscleres are easily lost is strong to-day, and for that reason I list the genus in an appendix to the Leiodermatiidae, as above. If Sollas' suborder Anoplia continues in use (as in Lendenfeld, 1903), the definition should read "usually without microscleres" instead of "without microscleres."

Taprobane should probably be merged, in the next revision of the group, into *Microscleroderma*. In respect to the vasiform body, skeletal framework, desma, oxeas, there is agreement. The appearance of the microscleres in *Microscleroderma* is peculiar (Kirkpatrick, 1902*b*, pl. 4, fig. 1*c*), but the text makes it evident that they are sigmas. The only differences seem to be that the sigmas are ectosomal in *Microscleroderma* and scattered through the body in *Taprobane*, and that the apertures of the afferent canals in *Microscleroderma* are perhaps not uniporal.

Genus TAPROBANE Dendy (1905).

Taprobane Dendy, 1905, p. 102.

Lamellate or vasiform sponges without special ectosomal megascleres: with minute uniporal apertures on both faces: with monocrepid tuberculate desmas, long slender oxeas, and sigmas.

TAPROBANE HERDMANI Dendy.

Plate 44, fig. 5

Taprobane herdmani Dendy, 1905, p. 103.

A dried specimen taken at station D5135 is referable to this species. Like Dendy's type it is vasiform, but growth has taken place in such a way that instead of one there is a complex of vases of different sizes arising from a common basal plate; the separate vases more or less fused. The smallest vase has almost the dimensions of Dendy's type, being 65 mm. high and 70 mm. across the top. The largest vase is 190 mm. high and 170 mm. across the top. The whole mass is about 200 mm. wide, greatest height 190 mm. The wall is about 10 mm. thick, somewhat thinner than in the type. The sponge like the type is dense and stony. Color, whitish. The surface is more even than in the type, and there are no barnacle galls.

Both surfaces, where not rubbed, are shaggy with projecting bundles of long oxeas. Dendy finds the afferent and efferent uniporal areas, on opposite surfaces, alike and 0.3 mm. in diameter. The efferent areas, covering the inner face, in the *Albatross* specimen are of about this size and closely set; the rims prominent, doubtless owing to the dried condition of sponge. The afferent areas, on the outer surface, are similar but slightly smaller.

The desmas agree with the type, the epirhabd in the adult spicule being curved, with a few clads on the convex side. When isolated with hydrofluoric acid, they give the measurements recorded by Dendy. The skeletal beams are richly tuberculate, the tubercles for the most part rounded and simple, but sometimes pointed and sometimes bifid. They may approach the rosette type (found in *Leiodermatium pfeifferae*, for instance), in that on and around a simple rounded tubercle, simple or bifid pointed processes are formed, as is indicated in one of Dendy's figures (pl. 4, fig. 2*c*). Developing desmas are abundant beneath the dermal membrane.

A point not mentioned in the description of the type is the radiate arrangement of the fenestrae (alveoli) of the skeletal framework. This is very marked in sections of the cleaned skeleton even to the unaided eye, the fenestrae appearing as rounded or squarish spaces, often about 200 μ in diameter, arranged in rows that are radial to the margin of the vase mouth and obliquely radial to the two surfaces. The intervening skeletal beams are mostly 100–200 μ thick.

In the type the oxeas are said to form "loose wisps or brushes, running at right angles to the surface, beyond which their ends project," disappearing more or less completely from the deeper parts of the sponge. The largest complete spicule measured reached only 1.88 mm. by 8 μ. The *Albatross* specimen seems to present a difference in this matter, for the oxeas are in compact and closely set bundles, often as thick as 100 μ, although sometimes much thinner. The bundles project, where the surface has not been rubbed, about 5 mm. The appearance is very much as in *Microscleroderma hirsutum* Kirkpatrick (Kirkpatrick, 1902, pl. 4, fig. 1*b*). The constituent oxeas vary greatly in size but reach a length of 10 mm. with a thickness of 40 μ.

The sigmas are 6–8 μ long, as compared with 10 μ for the type; otherwise there is agreement.

The type is from the Gulf of Manaar. Dendy (1921*b*, p. 7) has recently described specimens from the Indian Ocean.

* * * * * * *

Representatives of five of the nine recognized families are described above. The remaining four families, listed and in part discussed below, are not represented among the sponges studied.

Family NEOPELTIDAE.

Neopeltidae Sollas, 1888, p. 344.—Lendenfeld, 1903, p. 140.

Family SIPHONIDIIDAE.

Siphonidiidae Lendenfeld, 1903, p. 140.
Cladopeltidae Sollas, 1888, p. 317.

In this family (Siphonidiidae) since Lendenfeld's synopsis there have been recorded the following species: *Siphonidium ramosum* (O. Schmidt), Topsent, 1904, p. 63; *Plakidium* (new genus) *acutum*, new species, Lendenfeld, 1906, p. 360.

Family VETULINIDAE.

Vetulinidae LENDENFELD, 1903, p. 149.
Anomocladidae SOLLAS, 1888, p. 354.

Family DESMANTHIDAE.

Desmanthidae TOPSENT, 1893*b*, pp. XXXVI–XXXVII; 1894*b*, p. 311; 1898*b*, p. 231.—KIRKPATRICK, 1902*b*, p 176.—LENDENFELD, 1903, p. 144.

Lendenfeld (1903, p. 144) restricts the family to forms with tetracrepid desmas. But Kirkpatrick (1902*b*) uses it in the wider sense of Topsent, 1898*b*, to include those with monocrepid desmas as well. While this runs counter to the principle (Zittel's) followed in Sollas' system, according to which genera with tetracrepid desmas (Theonellidae) are separated from those with monocrepid desmas (Corallistidae, now Coscinospongiidae), it is in strict logic admissible since it sometimes happens that along with monocrepid desmas some tetracrepid ones may occur in the same individual even (O. Schmidt, 1879, p. 24; Sollas, 1888, p. 342; Topsent, 1904, p. 60). In the known instances of this combined occurrence of the two types, the aberrant (tetracrepid) desma includes a crepis, three rays of which are short and one long, and which is regarded as a degenerate tetraxon spicule. The family (Coscinospongiidae) in which these instances occur is defined as having a monocrepid desma. The occasional occurrence of imperfect tetracrepid desmas may be regarded as reversional. The case of the Desmanthidae is somewhat different, since here a form, *Monanthus*, with monocrepid desmas is combined with another, *Desmanthus*, having tetracrepid desmas (modified triaenes).

In addition to the single species given by Lendenfeld (1903) the list now includes *Desmanthus topsenti* (Hentschel, 1912, p. 307) and, using the family in the wide sense, *Monanthus* (new genus) *plumosus* (Kirkpatrick, 1902*b*).

Thiele (1899*b*) has suggested, but without sufficient reason, that *Desmanthus* is really a monaxonid sponge, and Kirkpatrick (1902*b*) touches on the same question with respect to *Monanthus*.

Thiele's suggestion (1899*b*) that *Monocrepidium* (new genus) *vermiculatum* (Topsent 1898*b*, p. 229), originally assigned to this family by Topsent, is a monaxonid sponge, allied to *Bubaris*, has been accepted by Topsent (1904, p. 148). In their external form and in the way they interlock, the megascleres of *Monocrepidium* present some analogies to the simple rodlike desmas of *Costifer vasiformis* of this report.

LITHISTIDA INCERTAE SEDIS.

BRACHIASTER, new genus.

BRACHIASTER SIMPLEX, new species.

Plate 51, figs. 8, 9.

A macerated lithistid was taken at station D5162, the desmas of which are of such a novel and interesting character that it is desirable to name the sponge, although, owing to the loss of the microscleres, it can not be placed in the classification.

Sponge lamellate, approaching a triangular shape, about 70 mm. wide, 8 mm. thick. The entire free edge is rounded and appears to be natural. One surface, slightly convex, is heavily incrusted with sand. The opposite surface is slightly concave and is cleaner. Sponge stony and yet in some slight degree flexible.

Only the desmas remain. They are tetracrepid and form a coherent skeleton, but on boiling in caustic potash or nitric acid a good many, in more or less perfect condition, separate out. In hydrofluoric acid, of course, they separate out completely. The young forms, which have not yet entered into articulation, are comparatively abundant.

The young forms are simple dichotriaenes (pl. 51, fig. 9*a*), or dichomesotriaenes (fig. 9*b*), or more complicated spicules (fig. 9*c*) in which the primary clads may bear three branches instead of two, the secondary clads again branching dichotomously or trichotomously, and in which one or both of the axial rays branch in similar fashion.

The adult desmas are obviously dichotriaenes or dichomesotriaenes in which the secondary clads and axial rays break up each into two or three terminal branches (pl. 51, fig. 8). The facets for articulation (*a. s.*) with other desmas are terminal or lateral on the branches or in the angles between branches. Some irregular variants of the type occur.

Holotype.—Cat. No. 21254. U.S.N.M.

The following macerated and unidentifiable lithistids were taken:

At station D 5172, a shallow cup-like sponge 70 mm. in diameter. Desma monocrepid.

At station D 5218, two specimens evidently of same species, the larger 80 mm. high. Sponge excavated by an axial cloaca of considerable size. Outer surface of skeleton labyrinthine, divided into trabeculae and lobes about 2–4 mm. wide by somewhat narrower meandering channels and spaces. Desma monocrepid with rosette-like tubercles resembling those of *Leiodermatium pfeifferae*.

At station D 5593, a vasiform sponge 60 mm. high, cloaca 30 mm. deep. Desma tetracrepid.

* * * * * * *

Hentschel (1912, p. 306) has described a new form, *Lophacanthus rhabdophorus*, which he points out does not fit in any of the families as these at present are defined. Pending some better arrangement, an appendix to the Theonellidae might be created for it to include forms without microscleres. The triaene concept of the family, already extensive, would have to be further enlarged to include mesolophotriaenes with degenerate rhabdome.

Order KERATOSA.

Ceraospongiae O. Schmidt, 1862, p. 19.
Keratosa Hyatt, 1875, p. 399.—Polejaeff, 1884, p. 38.
Ceratosa Ridley, 1884, p. 378.
Ceratina Vosmaer, 1887, p. 362.
Monoceratina part plus *Hexaceratina* part, Lendenfeld, 1889.
Euceratosa Dendy, 1905, p. 200.

Skeleton made up of horny fibers. Without proper spicules. Absence of spicules primitive and not due to evolution by loss. Sand grains and other foreign mineral particles often aid in forming the skeleton, and in exceptional cases constitute its chief part.

The families included are the Darwinellidae (Aplysillidae of some authors, Darwinellidae plus Aplysillidae of Lendenfeld, 1889), Pleraplysillidae Topsent (see George and Wilson, 1919, p. 166), Spongelidae, and Spongidae.

The group of true horny sponges, without proper spicules, was early recognized and embodied in the systems of Grant (1826, 1861) and Nardo (1833). Bowerbank's Keratosa (1864, p. 155), on the other hand, was made to include some sponges with proper spicules. The same is true of the Keratospongia of Gray (1867). Carter (1875) recognized the true horny sponges, but split them in two groups, Ceratina and Psammonemata, distinguished chiefly by quantitative differences in the foreign contents of the fibers.

Lendenfeld's monograph (1889) remains as the all-important handbook for practical work on the horny sponges. But his Hexaceratina, it would seem, should be deleted, and *Darwinella, Aplysilla, Ianthella, Dendrilla, Haddonella* (Igerna Sollas, 1903) combined with *Megalopastas* Dendy in the Darwinellidae (in the matter of the terminology of this family see George and Wilson, 1919, p. 164), as advocated by Dendy. Lendenfeld's Monoceratina is distinctly stated to be a polyphyletic group, and is therefore made to include forms with spicules and forms in which the spicules have obviously been lost, all conceived as transitional types from different stocks of the Halichondrina (Chalininae and various Desmacidonidae). Dendy (1905) made an important advance by clearing away these types, the similarity of which to the Keratosa he looks on as the result of convergent evolution, designating them as pseudoceratose forms. A monophyletic group (Euceratosa) is thus left, the basal family of which in Dendy's scheme is the Darwinellidae.

The genera included by Lendenfeld in the Monoceratina but which, from the point of view just stated, should be excluded as pseudoceratose sponges, are *Aulena* (assignable as Lendenfeld remarks, 1889, p. 90, to the Desmacidonidae—the other Aulenidae are probably distributable among the remaining Keratose families), *Chalinopsilla* (assignable to the Chalininae, see Lendenfeld, p. 121), *Phoriospongia* and *Sigmatella* (assignable to the Desmacidonidae—see George and Wilson, 1919, p. 153, where the subfamily Phoriosponginae is retained in an emended sense). Lendenfeld's subfamilies under the Spongidae continue to be useful in practical work

Family DARWINELLIDAE

Darwinellidae MEREJKOWSKY, 1878, p. 44.—VOSMAER, 1887, p. 366.—TOPSENT, 1905, p. clxxiii.—GEORGE and WILSON, 1919, p. 163.

Darwinellidae plus *Aplysillidae* LENDENFELD, 1889, p. 672.

Aplysillidae DENDY, 1905, p. 203; 1916*b*, p. 95.—ROW, 1911, p. 359.—HENTSCHEL, 1912, p. 429.

Keratosa with eurypylous and large flagellated chambers; with a skeleton composed of separate horny fibers that ascend from the base of the sponge and are simple or branched, or the skeleton may be reticulate; "spicules" of spongin may also occur; the spongin fibers contain a medulla or pith and lack foreign mineral particles.

Genus IANTHELLA Gray (1869).

Ianthella GRAY, 1869, p. 49.—POLEJAEFF, 1884, p. 22.—LENDENFELD, 1889, p. 683.

Large, lamellar or cup-shaped sponges, pedunculate below; lamella or wall thin as compared with area of sponge surface; surface conulose. Skeleton a coarse and regular reticulum, made up of large main fibers which radiate from the peduncle to the margin of the lamella, and connectives extending at right angles to the former. Main fibers fascicular and, sometimes, at any rate, bandlike, the bands set edgewise to the surfaces of the sponge; connectives simple, slightly fascicular, or resembling the main fibers in being very fascicular and bandlike. From the reticulum small simple fibers, originating at or between the nodes of the reticulum, pass vertically to both surfaces where they end in the conuli; these fibers sometimes branching in dendritic fashion. All (primary) skeletal fibers alike; hollow, the axial cavity surrounded by a noncellular pith, which in turn is surrounded by the spongin of the fiber; the latter containing abundant, regularly disposed cells or cavities in which cells once were, such cells presumably spongoblasts, once superficial but becoming engulfed during the growth in thickness of the fiber.

IANTHELLA FLABELLIFORMIS (Pallas).

Spongia flabelliformis Pallas, 1766, p. 380.

Ianthella flabelliformis Polejaeff, 1884, p. 37.—Ridley, 1884, pp. 392, 601.—Lendenfeld, 1888, p. 23 (older synonymy given in detail); 1889, p. 696.—Hentschel, 1912, p. 434.

Station 5145, one large dried specimen. Sponge a lamella 600 mm. high and about as wide, narrowing to a thick, short, stalk-like base; lamella in general about 4 mm. thick, at the very base fully 20 mm. thick. In the region of the stalk one surface is somewhat convex and one somewhat concave, this difference disappearing a short distance above the stalk. A difference between the two surfaces with respect to oscula, pores, and perhaps conuli, has been recorded for this species (Lendenfeld, 1889, p. 696; Hentschel, 1912, p. 434). But in the *Albatross* specimen oscula 2 mm. and less in diameter are, at any rate, abundant on both surfaces, and the conuli of the two surfaces are alike; pores indistinguishable. Color of specimen, black, but the natural color is known to be a bright yellow, which quickly changes on exposure to the air to a dark violet blue. The species may reach a height of 1,000 mm. (Lendenfeld, 1888, p. 23).

The radial fascicular fibers in the lower part of the sponge have the character of more or less cylindrical bundles, but throughout the body in general they form thin reticular lamellae, placed edgewise to the sponge surfaces and about 3 mm. apart; these are the bands mentioned by Lendenfeld. The connectives have the character of simple or slightly fascicular fibers, and the system of square or rectangular meshes formed by them with the radial bands is quite regular, closely resembling the photograph of *I. basta* given by Lendenfeld (1889, pl. 47). But, as recorded by Lendenfeld (1888, p. 24), the connectives in *I. flabelliformis* may form bands like those formed, doubtless through continual branching and anastomosis, by the radial fibers.

The specimen considering its area is thin for the species, and the conuli, distributed at intervals of about 3 mm. along the edges of the radial bands, are very low. They are not over 1 mm. high, and for the most part simple, occasionally divided close to the apex into two or three points. Correspondingly the supporting fibers of the conuli are simpler than has been recorded for some individuals, where they have been found to be dendritic (Lendenfeld, 1888; Hentschel, 1912). These fibers are in the *Albatross* specimen simple, slender, conical processes, sometimes divided near the apex, extending out from the edges of the radial skeletal bands. They bear no relation to the intersection points made by radial fibers and connectives, although in some other specimens (see Lendenfeld) they originate from such points.

Lendenfeld (1889, p. 683) recounts that this species has been known since 1713, when it was first described by Petiver under the name *Rete phillippense*. It has been recorded from the Philippines, Indian Ocean, Australian coast, Torres Straits, and the Aru Islands.

IANTHELLA BASTA (Pallas).

Spongia basta Pallas, 1766, p. 309.

Ianthella basta Lendenfeld, 1889, p. 695 (older synonymy given in detail).—Topsent, 1920*c*, p. 316.

Station D5139, pieces of fronds ("bands" of Lendenfeld) and one perfect frond 350 mm. long, 100–120 mm. wide, 2–3 mm. thick exclusive of conuli. Edge of this frond terminally and in part along both sides is the natural sharp edge of the sponge.

Main fibers about 3 mm. apart, in general vertical but curving more or less radially to the edge of the frond. Connectives transverse in usual way and mostly 2–3 mm. apart. Conuli sharp, distributed along edges of main fibers on both sides of sponge, 1 mm. or less high and 2–3 mm. apart. On one face the dermal membrane is riddled with pores which make the impression of being in areas, 120–180 μ in diameter, separated by narrow trabeculae. On the other face are minute oscula a fraction of a millimeter in diameter, typically in a single row between every two main fibers, and 1.5–3 mm. apart. Color in alcohol, reddish, shading off in places toward yellow.

The species has been recorded from the Indian Ocean and Australian seas (Lendenfeld, 1889; Topsent, 1920*c*).

Family SPONGELIDAE.

Spongelidae Poléjaeff, 1884, p. 23.—Vosmaer, 1887, p. 362.—Part Lendenfeld, 1889, p. 590.—Dendy, 1905, p. 207.—George and Wilson, 1919, p. 164.

Spongelidae Authors plus *Pleraplysillidae* part Topsent, 1905, p. clxxxiv.

Keratosa with eurypylous and large flagellated chambers, with a skeleton composed of separate horny fibers that ascend from the base of the sponge and are simple or branched, or the skeleton is more commonly reticulate. Horny fibers without pith, generally containing abundant foreign mineral particles. Skeleton may be reduced, then consisting of foreign particles usually held together by a little spongin, but the latter may be absent.

Genus SPONGELIA Nardo (1834).

Spongelia NARDO, 1834, p. 714.—O. SCHMIDT, 1862, p. 28.—F. E. SCHULZE, 1879, pp. 153–154.—LENDENFELD, 1899, pp. 641–649.

Skeleton distinctly fibrous, always including main fibers, these containing abundant mineral inclusions. Main fibers generally united by connectives but they may be separate and distinct dendritic structures. Connectives generally slenderer than main fibers, with or without mineral inclusions; but in some species with reticular skeleton main fibers and connectives are so much alike as to be scarcely distinguishable. Surface of sponge almost always conulated.

SPONGELIA FRAGILIS (Montagu), var. FASCICULATA new variety.

Plate 44, fig. 1.

Spongia fragilis MONTAGU, 1818, p. 114.
Dysidea fragilis JOHNSTON, 1842, pp. 187, 251.
Spongelia pallescens F. E. SCHULZE, 1879*b*, p. 138.

Two good-sized pieces from Togian Bay, Togian Island, Celebes. One specimen somewhat lamellate below, passing above into a solid cylindrical process 25–30 mm. in diameter that has been cut off; total height, 120 mm. The other is a solid cylindrical branch, tapering to the apex, 25–30 mm. in diameter and 170 mm. long. Quite possibly both pieces belonged to same sponge. The sponge then may be said to be ramose. Numerous oscula, mostly about 3 mm. in diameter, are scattered over one side of the lamellate portion and, what is of some interest, along one side of each cylindrical process. Consistency firm. Surface very dark brown, almost black, interior light in color.

Conuli about 3 mm. apart and 1 mm. high, not sharp but truncated apically; surface conspicuously depressed between the conuli. There is the usual dermal reticulum formed by narrow fibrous bands radiating from the apices of the conuli. Pores actually closed, but it may be seen that they occupy the meshes of this reticulum and measure 50–85 μ or thereabouts in diameter. The dermal membrane is smooth, without sand. Parenchyma fairly dense, but besides the main oscular canals there are numerous small canals, $\frac{1}{3}$ mm. to 1 mm. in diameter, which extend in more or less radially from the surface. There are no subdermal cavities of large size. The flagellated chambers measure 60 by 50 μ to 70 by 60 μ. The parenchyma contains large numbers of sperm balls (sponges were taken in November).

Radial main fibers terminate in the conuli (pl. 44, fig. 1, from a section vertical to the surface). Between these, connectives are richly developed. The radial main fibers are about 2 mm. apart in the peripheral sponge body; fascicular and generally 300–500 μ thick; composed of a close reticulum of slender individual fibers, the latter 50–85 μ thick and completely filled with foreign particles, chiefly sand.

Connectives mostly 70–85 μ thick; thicker ones are sometimes formed by the lengthwise fusion of slender fibers; connectives in general completely filled with foreign particles, chiefly sand, but not infrequently considerable spongin shows round the sand core. The connectives extending between two adjacent radial fibers establish coarse reticula, meshes mostly 300 μ to 1 mm. wide, but the range is from less than 300 μ to 2.5 mm.; the very large meshes lie between connectives which are simple, that is, unbranched or only slightly branched. When this skeletal arrangement is cut transversely, as in sections parallel to the surface of the sponge, it exhibits a comparatively uniform meshwork, the meshes mostly 1–2 mm. wide.

There is no proper dermal skeletal reticulum, but just below the dermal surface the most peripheral of the connectives form a tangential network which may be designated a subdermal reticulum. This is perforated by rounded spaces, for the radial canals, 1–2 mm. in diameter. Such spaces are commonly about 2 mm. apart, the intervening reticulum showing meshes which grade down from 1 mm. to about 150 μ in diameter.

Holotype.—Cat. No. 21299, U.S.N.M.

F. E. Schulze in his classical essay on *Spongelia* (1879*b*) recognizes (p. 127) the impossibility of separating the group of Adriatic forms into sharply distinct species. Intermediates occur between all subdivisions, and holding this in mind all the Adriatic *Spongelias* (*avara*, *pallescens*, *elegans*, *spinifera*) might be regarded as varieties of one species.

Under the name of *S. pallescens* O. Schmidt, Schultze (1879*b*, p. 138) combined with that sponge several others of Schmidt's (1862, 1864) *Spongelias*. In the species so conceived Schulze finds (p. 141) the form, consistency, and color variable. The conuli are fairly uniform, 1–3 mm. high and 1–3 mm. apart. Radial main fibers and connectives are readily distinguishable. The main fibers, 1.5–2 mm. apart in the body of the sponge, terminate in the conuli, and are thickly filled with foreign particles, chiefly sand grains. No mention is made of any tendency in the main fibers to become fascicled. The connectives are cylindrical and considerably thinner than the main fibers, sometimes completely filled with foreign particles, sometimes practically without such, the two extremes connected by intermediates. The connectives vary also as regards richness of development: sometimes sparsely and regularly developed, the resulting net work coarse and ladder-like, with meshes that are often about 2 mm. wide (1879*b*, pl. 7, fig. 6); or again so richly developed as to form a network as close as in *Euspongia officinalis;* intermediates connect these extremes.

Schulze's account makes it plain that *Spongelia pallescens* can not be *split up* into distinct subgroups. The different forms to which he gives the names of subspecies and variety are, as he says (p. 149), only types within the species and not subdivisions. These types he regards (but here he is, one suspects, only in part on solid ground) as forms which owe their differential peculiarities to the local environment. With this understanding, Schulze makes two subspecies, *fragilis* and *elastica.* In *fragilis* not only the main fibers but the connectives, which are usually sparsely developed, contain abundant foreign bodies. Within this subspecies the body may be incrusting, or growing up into branches, the branches in some specimens tubular, in others solid. Such types (*formae* in our current terminology) he distinguishes as varieties *incrustans*, *tubulosa*, and *ramosa.* In the other subspecies, *S. pallescens elastica*, the connectives for the most part are without foreign particles and form well-developed reticula. In this subspecies the body may be massive (var. *massa*) or more or less branched, the branches generally solid (var. *lobosa.*) A tendency is noted for differential color characteristics to be associated with the structural subspecific characters.

Lendenfeld (1889) separated Schulze's two subspecies as distinct species, *S. fragilis* and *S. elastica*, but the facts stated above would seem to show that the separation is artificial and that the single species should be maintained in Schulze's sense. Schmidt's name of *pallescens* (1862) employed by Schulze must, however, give place to *fragilis*, since Lendenfeld has shown (1889, p. 642) by direct comparison that *Dysidea fragilis* (Montagu, 1818) Johnston, 1842, is identical with Schulze's subspecies *fragilis.* The name of the species, conceived in Schulze's sense, thus becomes *S. fragilis* (Montagu). I suggest that *elastica* be set off as a variety. The Philippine sponge may be set off as another variety, *fasciculata*, distinguished by the fascicular character of the main fibers. It approaches the type in that the connectives contain foreign particles, *elastica* in that they are richly developed. Doubtless with continued study other combinations—as, for instance, fascicled main fibers with sparsely or richly developed connectives free from foreign particles—will be discovered. As numerous combinations of characters come to be known within a group ("species") which can not actually be split into subdivisions owing to the occurrence of intermediates, it comes to be a question as to what method of notation we shall employ in the designation of individuals. Perhaps we shall have to limit ourselves to the erection of a certain number of standard combinations (varieties or subspecies) and designate nonconforming individuals as *near* certain of these standard forms.

With regard to the fascicled character of the main fibers in *Spongelia* it may be called to mind that Hyatt (1877, p. 545) states that in the specimens which he refers to *Dysidea fragilis* Johnston the primary fibers are often compound. Schulze (1879 *b*, p. 124) refers to this fact, and further on (p. 151) in the same memoir describes fascicular main fibers in *S. elegans* Nardo. In *S. fragilis*, var. *implexa*, from Australian waters, Lendenfeld (1889, p. 666) says "exceptionally a fascicular structure is indicated in the areniferous main fibers, 0.17–0.2 mm. thick." Wilson records (1902, p. 410) that in the Porto Rican sponge referred to *S. pallescens fragilis*, var. *ramosa*, the main fibers are somewhat fascicular.

Since Lendenfeld's monograph (1889), where the distribution is given, the species has been taken several times. Topsent lists it for the Azores (1892) and again for Amboina (1897). Dendy (1905) refers Ceylon sponges to it, splitting the species after Lendenfeld into *S. fragilis* and *S. elastica*. Hentschel (1921) lists two varieties from the Aru Islands. Stephens (1912, 1917) records the species from the Irish coast. Dendy (1916 *b*) records it from Okhamandal and questions (p. 139) the desirability of separating *S. elastica* from *S. fragilis*. It would seem that the species name is used by all these authors in the limited sense of Lendenfeld's monograph.

Family SPONGIDAE.

Spongidae LENDENFELD, 1889, p. 121.

Sponges with small flagellated chambers, 20 to 50 μ wide, and a skeleton, generally in the shape of a reticulum, composed of solid, or pithed, horny fibers. In exceptional cases the whole fiber may consist of pith-substance.

Subfamily EUSPONGINAE.

Eusponginae LENDENFELD, 1889, p. 123.

Skeletal reticulum close-meshed, the fibers solid, containing only a narrow medullary streak instead of a conspicuous pith as in the Aplysininae. Main and connective fibers generally distinguishable; all fibers simple, none fascicular. Main fibers usually with foreign bodies, which are, however, in general small, not distending the fiber.

Genus PHYLLOSPONGIA Ehlers (1870).

Phyllospongia EHLERS, 1870, p. 30.—LENDENFELD, 1889, p. 154.
Phyllospongia plus *Carteriospongia*, HYATT, 1877, pp. 540, 543.

Thin lamellate Euspongiinae, often cup-shaped; frequently with a sand cortex.

The genus has been defined or species recorded by Keller, 1889–91, Lendenfeld, 1897, Topsent, 1897, Thiele, 1899, Dendy, 1905, Topsent, 1906, and Row, 1911.

PHYLLOSPONGIA FOLIASCENS (Pallas).

Spongia foliascens PALLAS, 1766, p. 395.
Phyllospongia foliascens LENDENFELD, 1889, p. 196 (older synonymy in detail).

Four specimens, all dried: three from the Sulu Archipelago, fourth (label lost) probably from same region.

There may be some disagreement as to the specific identity of all the various forms grouped together by Lendenfeld (1889, p. 196) under *P. foliascens*, and it is well to state that the *Albatross* specimens are of the type designated *Halispongia ventriculoides* by Bowerbank (1874 *b*, pl. 47, fig. 2) and *Carteriospongia radiata* by Polejaeff (1884, pl. 4, fig. 5). Lendenfeld's figure (1889, pl. 24, fig. 6) represents a specimen of this type.

The largest specimen taken along shore of Simulac Island, Tataan Pass, is a conical vase 200 mm. high, 250 mm. across the mouth; wall, halfway between base and margin, 4 mm. thick. Oscula, 0.5 to 1 mm. in diameter, are abundant on the inner face, absent on the outer face, of the vase. The reticulate appearance of the two surfaces departs slightly from Lendenfeld's description (1889, p. 197), in that the polygonal dermal areas, which are marked off from one another by narrow furrows, are distinctly larger and narrower on the outer than on the inner (oscular) surface. These dermal areas, it may be added, are produced by clusters of closely set radial skeletal fibers, which are absent along the furrows. As in the specimens examined by Lendenfeld, there are no horny fibers in the dermal membrane, only a "sand-cortex" made up chiefly of sand grains with intermingled fragments of spicules. Lendenfeld's description of the skeleton (p. 198) applies on the whole satisfactorily to this specimen.

A second specimen from same locality as the first is flabellate, 130 mm. high and considerably wider, divided above into lobes. The surfaces are intact, and it may be seen that the oscula, about 1 mm. in diameter, are confined to one side of the lamella, on which they are abundant. The dermal areas are, as in the first specimen, larger and narrower on the outer (nonoscular) surface; or they are simply smaller.

A third specimen, a shallow vase 50 mm. high, 70 mm. wide, was taken along the shore in the vicinity of Ramblon. The dermal areas, of course, vary, but there is the same general difference between the two surfaces as noted for the first specimen.

The fourth specimen, locality unknown, is flabellate, 75 mm. high, 130 mm. wide. In the upper part there is the same difference between the two surfaces, in respect to the dermal areas, as in the first specimen. In the lower part of the body, the nonoscular (outer) surface is minutely tuberculate, owing to the subdivision of the clusters of radial fibers which support the dermal areas in the typical surface pattern.

Lendenfeld (1889, p. 199) gives the distribution in detail, recording numerous localities in the Indian Ocean, including the Philippines, Tropical Pacific, and Australian Seas. Since his monograph, the species has been taken several times. Keller (1889–91) and Topsent (1906) record it for the Red Sea. Topsent, however, expresses some doubt as to the specific identity of the forms grouped together by Lendenfeld, and notes that the particular form studied by him is that recorded by Hyatt (1877, p. 541) as *Carteriospongia otahitica*. Topsent also records the species from Amboina (1897, p. 483), and Lendenfeld (1897, p. 124) from Zanzibar. Topsent (1920*c*, p. 317) has recently added *Spongia penicillata* Esper to the list of synonyms of this species.

PHYLLOSPONGIA ALIENA, new species.

Plate 51, fig. 10; plate 52, figs. 1, 3, 5.

Station D5174, one specimen (alcoholic). Sponge, a vase 120 mm. high and about as wide across the mouth; wall of vase 8 mm. thick. Outer surface smooth, without oscula. Inner surface appears granular to the eye, with numerous oscula 1 mm. to 1.5 mm. in diameter. Color, whitish.

Outer surface occupied by rounded pore areas about 100 μ in diameter, without skeleton, separated by narrow trabeculae, 30–40 μ thick, full of sponge spicules and sand grains, and forming a reticulum. No horny fibers in the dermal membrane of this or the inner surface.

Inner surface likewise exhibits a dermal skeletal reticulum, the trabeculae of which are made up of spicules and sand grains. But this is interrupted by very numerous aggregations of sand and spicules, to which is due the granular appearance of this surface. Perhaps this appearance of both surfaces, as respects detail, varies with the closure or opening of the pores. Flagellated chambers 30–40 μ in diameter.

The spicules and sand grains at outer and inner surface constitute a "sand cortex" about 700 μ thick (pl. 51, fig. 10, *s. c.*). Fibrous skeleton includes a reticulum in the middle layer of the sponge wall, slender radial fibers (*r. f.*) diverging from this on both sides, and very peculiar connectives.

Skeletal reticulum in the middle layer of the wall is scanty, its fibers charged with sand grains and spicules, and not much, if any, thicker than the radial fibers. The radial fibers are slender, 85 μ and less in thickness, laden with sand grains and sponge spicules; regularly arranged, projecting outward and upward, and about 400 μ apart; frequently uniting in pairs to form a fiber of the mesial reticulum.

The connectives are long, slender, smooth, cylindrical fibers, of very uniform thickness, 24 to 28 μ thick; without inclusions. They are very abundant in all parts of the sponge, intertwining and crossing one another and the main skeletal fibers (pl. 51, fig. 10; pl. 52, fig. 1). They run in all directions, but very many extend parallel to the surfaces of the sponge and thus cross the radial fibers; of these again, very many extend lengthwise (vertically in the upright sponge). The fibers branch dichotomously now and then, but only very rarely. They are united with one another not by the anastomosis of branches, but chiefly by short transverse bars of spongin (pl. 52, fig. 1, *sy*), to which the term synapticula (borrowed from the Hexactinellida) may be applied. The synapticula, which only very rarely contain inclusions (spicules), are abundant, and thus the fibers are combined together in reticular fashion.

These fibers are very long, but how long I do not know. Perhaps they connect, as branches, lower down in the sponge with the system of main fibers. Where they cross one another or cross the main (including radial) fibers, the crossing fibers are commonly cemented together by little masses of spongin (pl. 52, fig. 3, *sp.*). Here and there, but only rarely, a connective is united to a radial fiber in the way that is usual in horny sponges. This is true of fiber *a* (pl. 52, fig. 1), the connective appearing to arise as a lateral branch from the radial fiber. Occasionally the end of a connective is found constituting a spongin expansion on the side of another, as in the case of fiber *a* (pl. 52, fig. 5). Summarizing, it may be said that in this species the connectives are represented by long, independent fibers, which are united with the main fibers and with one another almost exclusively by short bars of spongin (synapticula) or by little masses of spongin.

The connectives show a very narrow medullary streak; this is more conspicuous near the end of the fiber than elsewhere (pl. 52, fig. 5). The substance is stratified, as may be seen in side view of the fibers, near the end (pl. 52, fig. 5), or in cross sections of the fibers. The fibers have a very definite sharp contour, as if the outermost layer were smooth and hard, making a kind of cuticle. The spongin, which serves as cement, has itself a sharp contour, but this is not as "cuticular" in appearance as the surface layer of the fibers, although the difference is one of degree. At the free end of the fiber (pl. 52, fig. 5) the outer layer is no more cuticular in appearance than is the case with the spongin cementing the fibers together. The substance of the fiber has the color and appearance of spongin, appearing distinctly yellow when a sufficient thickness of material is looked at.

When the sponge is macerated for some time in cold caustic potash, some of the connectives remain unbroken, the substance appearing translucent and homogeneous; the medulla is made more distinct and often looks granular; it may be locally widened and very conspicuous (artifact). More often the connectives are split, more or less, into shreds and tatters by the potash; the substance may at first sight seem to be fibrous, but this appearance is due to the splitting and to the laminated structure of the substance. The sharp contrast between outer layer and inner substance disappears in such macerations, the pieces of a split fiber all looking alike, firm and yellow, presenting the same appearance as the synapticula of spongin. There thus can be no doubt that the connectives are made up of spongin.

After boiling in weak caustic potash (5 per cent) for a minute or two, some of the connectives are changed in a significant way. The medulla is made more distinct and is shown to widen out a little at the end of the fiber; the surface layer is wrinkled, indicating that the inner substance is softer than it; at fractured ends the inner substance may protrude in unbroken condition for some little distance beyond the outer "cuticular" layer. In fibers broken across in this way, the fractured surfaces of the inner substance stain easily with haematoxylin, whereas with the same stain and time the unbroken fiber stains scarce at all. All these appearances indicate that while the fiber is made up of spongin the outermost layer is especially hard and dense.

After being just brought to a boil in strong (50 per cent) nitric acid, the distinction between surface layer and inner substance of the connectives disappears, and the whole fiber tends to split up as in cold caustic potash, the outer layers sometimes peeling off from an inner core. Boiling for a couple of minutes in this strong acid indicates that the fibers are less resistant than the synapticula; the former, in my preparations, had been very largely dissolved, while plenty of synapticula remained.

These connectives are much like many of the connectives of *Euspongia officinalis*, but the almost complete absence of the branching and anastomosing habit gives them a strikingly independent appearance, and the way in which they are secondarily united by synapticula and amorphous little masses of spongin is very peculiar. They seem at bottom to be ordinary spongin fibers and quite different things from Hircinia filaments, a resemblance to which may possibly be suggested by the mere verbal description.

I find that slender cylindrical connectives with a narrow medullary streak, in general quite similar to the connectives of *P. aliena*, occur here and there as constituents of the skeletal network in my preparations of *P. foliascens*, and are in places united by spongin synapticula quite as in *P. aliena*. Further, they are distinguishable in many parts of the skeletal network of this species (*foliascens*) as axial cores round which stratified spongin has been deposited. In fact, I suspect that the skeletal reticulum of *P. foliascens* is built up very largely on a primary foundation of cylindrical connectives like those of *P. aliena*.

Holotype.—Cat. No. 21288, U.S.N.M.

Genus EUSPONGIA Bronn (1859).

Euspongia Bronn, 1859.—Lendenfeld, 1889, pp. 222–223 (synonymy in detail).

Skeletal network pretty evenly developed throughout the often massive, but also vasiform, lobose, digitately branched, or lamellate body; all fibers, slender; meshes very small, not or scarcely perceptible to the eye. Main fibers simple, terminating, as a rule, singly in the conuli, but the main fiber may break up into two or three branches all of which terminate in one conulus; main fibers with inclusions; connecting fibers uniformly cylindrical, without inclusions, branching and continually anastomosing.

EUSPONGIA OFFICINALIS (Linnaeus).

Spongia officinalis Linnaeus, 1735.

Euspongia officinalis Lendenfeld, 1889, p. 262 (synonymy in detail).

The collection includes 15 cut pieces all taken on same day, August 26, at Hinitungan, and representing a number of sponges, all massive and 80–180 mm. in diameter. They are all alike. The conuli are sharp, about 1 mm. high and 1.5–2 mm. apart, commonly connected by ridges, the intervening areas depressed in the usual way. The radial skeletal fibers frequently protrude at the conuli, singly or two or three in one conulus. A number of oscula, 4–9 mm. in diameter, on upper part of sponge. Surface blackish, lighter in lower part of sponge; interior yellowish brown to reddish. Several of the sponges with eggs.

In them all the conuli are higher, the ridges more prominent, and the depressed areas deeper in certain regions than is common. Such regions doubtless represent areas in which contraction had proceded quite far.

Main fibers of a region nearly parallel to one another, vertical to surface, 40–50 µ thick, well filled with spicule fragments but containing no, or almost no, sand grains. Fibers in the peripheral part of sponge are 900–1,800 µ apart. As a rule the fiber terminates singly in a conulus, but it may branch at very acute angles, the two or three branches terminating together in a single conulus. Connectives are of uniform thickness, about 20 µ thick, and contain no foreign inclusions; characteristic meshes 90, 180, 270 µ in diameter.

In addition to the above, three small specimens of massive shape, 50–60 mm. in diameter, were taken along the shore of Busin harbor, Burias Island. Conuli less than 1 mm. high, and less than 1 mm. apart. Oscula 2–4 mm. in diameter, many sphinctrate. Main fibers in peripheral part of sponge, 700–1,200 µ apart. In the remaining features mentioned above, these sponges agree with the larger ones and are therefore to be regarded as young (see below) forms of the same race.

Some of the recognized varieties (Lendenfeld, 1889) of *Euspongia officinalis* are well marked, although perhaps certain of them are only habitus forms. Others are vaguely delimited by quantitative differences which are too slight to be relied upon with any great certainty in the practical work of classification. It would probably be a good provisional step in the handling of collections, which do not permit the rich detailed comparisons between many individuals (young and old, in various kinds of habitat, and in different physiological states) that come with a residence in the working-field of a laboratory, to reduce the number of varieties, recognizing by name only such as depart conspicuously from a type which itself is conceived, in accordance with the facts, as not uniform but heterogeneous in respect to detail.

Thus I find that, as far as recorded data allow one to form a judgment, the Philippine sponges above described can not be separated from Dendy's variety *ceylonensis* from the Gulf of Manaar (Dendy, 1905, p. 211) nor, on the other hand, from the Porto Rico specimens which I referred (1902, p. 402) to var. *rotunda* in the sense of Lendenfeld (1889, p. 269), under which name Lendenfeld combined numerous West Indian and Florida forms that had been distinguished especially by Hyatt. From these the Mediterranean variety *adriatica* is not very distant, although possibly specimens of *adriatica* might be picked out from the others by the larger average size of the meshes and thickness of the connectives and by the fact that the foreign bodies in the main fibers are chiefly sand grains.

In listing the small specimens from Burias Island (see above) as young forms, I would add that they may be young in respect to time, or possibly only in respect to growth stage regardless of actual time age. I have in mind such cases as that of *Microcioma prolifera* Verrill (see George and Wilson, 1919), in which species we find thin incrusting forms and erect ramose forms together with intermediates, all breeding. The abundance of the incrusting type in Beaufort (N. C.) harbor, coupled with the comparative scarcity of the ramose forms, makes it probable that the sponge very often stops its growth, owing to environmental conditions, in the incrusting stage. Incrusting *Microcionas* may therefore, on this hypothesis, sometimes be quite as old in time as many a ramose specimen.

EUSPONGIA IRREGULARIS Lendenfeld, var. SURIGANENSIS, new variety.

Euspongia irregularis LENDENFELD, 1889, p. 245.

Station D5478 (vicinity of Surigao Strait), one specimen with an attached *Myriastra siemensi.* Sponge an amorphous, thin, flattened mass sending off subcylindrical branches which, in part, fuse with one another, thus producing a very irregular body. Dimensions of whole sponge 150 by 60 by 50 mm. Branches 5–10 mm. in diameter, length of longest free branch 50 mm. Oscula 3 mm. in diameter scattered over upper and lateral surfaces; all elevated more or less, the elevation in a few cases low, in most cases forming a tubular projection (cloacal tube) 8–13 mm. high by 3–4 mm. in diameter. Wall of cloacal tube very thin, inclosing a single cavity into base of which open several efferent canals. Osculum at apex of the tube is open in a number of cases; in others closed, but otherwise such tubes are like the open ones. In all about 20 such tubes are present. Surface of sponge in general with conuli 2–3 mm. apart and 1 mm. or less in height. Conuli over much of the surface interconnected by the usual sharp ridges with depressed areas between; distinctness of ridges doubtless varies with the contraction state. There are numerous smooth aconulous areas, several of them extensive; all apparently on sheltered parts of the surface. Sponge not as uniformly dense as *E. officinalis.* Color, lead gray, variable.

Dermal membrane is smooth, without sand, but containing plenty of spicule fragments; underlaid by subdermal cavities visible to eye. There is the usual dermal reticulum of fibrous bands with pores in the meshes, the larger interconular bands containing a good many spicules arranged lengthwise and looking almost like skeletal fibers. Flagellated chambers 40–44 by 30–36 μ.

Main fibers terminating singly in the conuli, mostly 42–56 μ thick, expanding here and there to as much as 77 μ thick; 2–3 mm. apart at surface, closer together in interior; containing no sand, only spicule fragments; these filling the fiber in the conuli, but less abundant in interior of sponge. Connectives and skeletal net show the irregularities (as compared with *E. officinalis*) characteristic of the species. Connectives in general 28 μ thick, but smaller ones also abundant, varying down to 10 μ thick: distribution of latter varies a good deal, however, for in some parts of a section all of the fibers are of about one thickness, 28 μ. The finer connectives are pretty well marked off from the larger, extending between the latter and subdividing the spaces embraced by them. These spaces vary from polygonal meshes as definitely bounded as in *E. officinalis* to elongated spaces which often are indefinitely bounded at one end. Typical meshes embraced by the larger fibers have the following dimensions: 700 by 250 μ, 420 by 245 μ, 350 by 280 μ, 350 by 350 μ, 280 by 210 μ, 210 by 77 μ. The smaller meshes produced by the finer connectives range down to 70 μ wide.

Holotype.—Cat. No. 21263, U. S. N. M.

In the possession of slender, cylindrical cloacal tubes (fistulae) the *Albatross* sponge agrees with *E. irregularis*, var. *fistulosa*, from the Bahamas (Lendenfeld, 1889, p. 249), but these are massive more or less spherical sponges, which in other respects also are not especially close to the *Albatross* form. In its branching habit, also in the possession of aconulous areas and small oscula, the latter resembles var. *jacksoniana* from Australian waters (Lendenfeld, 1889, p. 254). But in var. *jacksoniana* there are no cloacal tubes, and the main fibers are 100 μ thick with a dense axial column of large sand grains. Another branching *Euspongia* is *E. tenuiramosa* from Ceylon (Dendy, 1905, p. 213), but without other special resemblances to var. *suriganensis*. It is plain that a practically infinite number of combinations of characters is possible, and may in fact now exist, in these sponges, owing to the independent variability of features. The new varietal name is given to the form simply that the combination which it represents may not be lost sight of.

Lendenfeld (1889) gives the distribution of the species. Topsent (1897, p. 484) has since recorded it for Amboina, and Hentschel (1912, p. 435) for the Aru Islands.

Subfamily APLYSININAE.

Aplysininae LENDENFELD, 1889, p. 335 plus *Psammaplysillidae* KELLER, 1889, p. 358.

Skeletal fibers contain a conspicuous axial pith or, more rarely, are composed entirely of pith substance.

Genus PSAMMAPLYSILLA Keller (1889).

Psammaplysilla KELLER, 1889, p. 358, pl. 22, figs. 23–27.

Fibers consisting of a minutely reticulate pith substance, which is sometimes imperfectly surrounded by a very thin development of spongin. Fibers not cylindrical and smooth but irregular in outline, aggregated and anastomosing to form skeletal tracts, which may be compact enough to deserve the name of compound fibers; between such tracts, extensive askeletal areas.

PSAMMAPLYSILLA KELLERI, new species.

Plate 44, fig. 3.

Togian Bay, Togian Island, Celebes, two specimens. Sponge a branching species; several long, slender branches rise from a common basal part, the branches fusing here and there at points of contact. Branches up to 160 mm. long, somewhat flattened, tranverse diameter 5–12 mm.; covered with conuli a few millimeters apart, these interconnected by sharp ridges which pursue in general a longitudinal course. Surface in these specimens smooth and without apertures visible to the eye. Sponge firm and compact but flexible; of a reddish-purple color.

Very small pores are scattered thickly over the surface; from them fine pore canals lead through the ectosome. Sections show here and there small canals, which yet are somewhat larger than the average pore canal, perforating the ectosome and opening on the surface; one such measured 20–25 μ in width; possibly these are oscular canals.

There is a thin surface cuticle and a fibrous layer in the deeper part of the ectosome. The mesenchyme is abundant, with many small cells containing pigment. The flagellated chambers are small but vary a good deal in size in the actual specimens, probably in part owing to contraction. They are ellipsoidal and measure 40 by 30 μ, 40 by 20 μ, 36 by 28 μ, and in some places only 24 by 14 μ. When cut crosswise they appear circular. Conspicuous ducts leading to and from them are absent.

Skeletal fibers predominantly located in the more axial part of body and largely longitudinal, branching and combining to form a skeleton which is most irregular in its distribution; in places it is closely reticular but extensive areas are quite without a skeleton. Some of the fibers extend outward and terminate in the conuli. Such conular fibers diminish in thickness as they reach the surface, and close to the surface may be only 30–40 μ thick although frequently larger; somewhat further in, a characteristic conular fiber measures 80–90 μ in thickness. Individual fibers of the inner skeleton are for the most part 120–350 μ thick.

The (individual) fibers are very irregular in shape, the same fiber varying markedly in diameter even within a short length. They are abundantly covered with bulbous enlargements or, in places, with more elongated outgrowths. The whole fiber presents the appearance of a body which grows by budding.

The structure of the fibers, apart from their shape and arrangement, is remarkable. They are either entirely, or almost entirely, composed of a minute reticulum, the meshes of which are about 4 μ in diameter, the strands very fine and yellowish in color. Whatever surface layer a fiber has is, in many cases, only a part of the general reticulum which forms the body of the fiber, not differing from it. But in other cases the general reticulum is strengthened at the surface of the fiber by thicker bands, having the appearance of spongin, which run lengthwise but anastomose and form a superficial coarse reticulum. Such a surface structure appears to be only a differentiation of the general reticulum and not something apart from it. The fibers exhibit (pl. 44, fig 3) a coarse and conspicuous concentric stratification. Sometimes bits of spicules and often small spheroidal groups of deeply pigmented cells occur in the interior of a fiber, several of the latter often close together. The latter inclusions are prehaps connected with the origin of the fiber, which possibly could be worked out on this material. The fibers, as might be inferred from their structure, are not hard enough, in spite of their size, to offer any great resistance to sectioning.

Holotype.—Cat. No. 21291, U.S.N.M.

Keller's *Psammaplysilla arabica* (1889) is a common species in the Red Sea. Incrusting, cake-shaped, and more or less conical or massive specimens occur. Sponge is firm and leathery; when dried, stony hard; covered with large conuli; oscula scattered. Skeleton consists of distinct compound fibers which ascend from the base of sponge, each soon breaking up into a reticulum of individual fibers. The individual fibers are irregular and lobulated in outline (Keller, 1889, pl. 22, fig 27) and usually contain abundant sand grains. They are concentrically stratified in a coarse and conspicuous fashion and consist entirely of a finely reticulate material that is similar to the medulla of the *Aplysilla* or *Aplysina* fiber. Pigment cells are abundant in the mesenchyme, especially near the surface. The living sponge is of a bright leather color at surface, yellow inside; in alcohol, black violet. Character of flagellated chambers unknown. The sponge has also been recorded by Topsent, 1892*b*, for the Red Sea.

Keller made this interesting sponge the type of a new genus and family (Psammaplysillidae) which he derived from the Aplysillidae. His material did not, however, permit of the study of the flagellated chambers, and as Dendy (1905, p. 244) has pointed out the relationship is probably with *Aplysina* and not, as Keller thought, with *Aplysilla*. I assume, until the sponge is studied again, that this is the case. If it should turn out that the canal system is really of the *Aplysilla* type, the striking resemblance between the fibers of the *Albatross* sponge and Keller's type would have to be looked on as a case of analogical resemblance. We should have to conclude, in other words, that both in *Aplysilla* and *Aplysina* certain offshoots had developed the morphogenetic habit of not secreting a firm spongin layer on the outside of the fibers. In case all this, which seems very unlikely, should turn out to be so, the *Albatross* sponge should be received into a new genus close to *Aplysina*. The character of the fibers is so peculiar as to deserve generic value, although the sponge is obviously related to *Aplysina* and *Dendrospongia*.

Schulze, 1878 (p. 401), first pointed out that the medulla of the *Aplysina* fiber is finely reticular in structure. He notes also (p. 399) that in young fibers the spongin wall may be only one-thirtieth to one-tenth total diameter of the fiber, although it increases not only in absolute but in relative thickness as the whole fiber grows thicker. In *Aplysilla* he finds (1878, p. 411) that the finer structure of the fibers is essentially as in *Aplysina*. Lendenfeld (1889, p. 398) says that the pith in the *Aplysina* fiber shows a reticulate structure. He records species (p. 416) in which the pith forms nine-tenth of the thickness of the fiber, the surrounding spongin forming only a very thin, although laminated, coating. In Porto Rican specimens of *Aplysina flagelliformis anomala* and *Dendrospongia crassa* I find that the pith is composed of a minutely reticulated substance. The pith of these fibers or the pith plus the very innermost spongin evidently corresponds to the whole fiber of *Psammaplysilla*.

Another sponge must be considered in this connection. This is *Aplysina purpurea*, first described by Carter, in 1880, from Ceylon, and later (1881*b*, p. 103) more fully described by him, the distribution being extended to Australia. Dendy (1889, p. 97; 1905, p. 224) has studied Ceylon (Gulf of Manaar) specimens of this species. The sponge is more or less conical or massive; conulated; may reach 195 mm. in height. The skeleton is composed of dense local aggregations of very irregular, branching and anastomosing horny fibers accumulated along certain tracts to form the so-called compound fibers, while large intervening areas remain free from fiber altogether. The fibers themselves have a very curious structure, consisting of a very thin outer layer (if any) and a very thick pith, the latter exhibiting a granular or often minutely reticulate appearance. They are free from foreign bodies (Dendy 1905). Dendy concludes that Keller's *Psammaplysilla arabica* is very closely related to, if not identical with, *A. purpurea*. Carter (1881*b*) says that in *A. purpurea* the ectosome (dermal sarcode) is fibrous below, with abundant pigment cells. The color in alcohol is black purple. What Carter terms horn cells (1881*b*, pl. 9, fig. 1*e*) are doubtless, as he concludes, stages in the development of the fibers. Their irregular shape in transverse section constitutes a point of resemblance to *P. arabica* and *P. kelleri*. Altogether it would seem that *Aplysina purpurea* must be regarded as the type of the genus to which I would in any case refer the *Albatross* sponge.

Row (1911, p. 377) refers a Red Sea sponge to *A. purpurea*. Hentschel (1912, p. 437) has studied a specimen from the Aru Islands. The individual fibers give very irregular cross sections and are variable (same fiber) in thickness, although often 200–300 μ thick, pith occupying nine-tenths or more of total thickness; the compound fibers measuring up to 2 mm. thick.

The resemblance between the fibers of *Psammaplysilla* and *Druinella* Lendenfeld deserves noting. In *D. rotunda* Lendenfeld, from Australian waters, the fibers show in cross section the same irregular lobose shape and coarse stratification (Lendenfeld 1889, p. 425, pl. 34). In Thiele's *D. ramosa*, from Celebes, the fibers show the same shape (Thiele, 1899, p. 24, pl. 4). Finally, the resemblance may be noted that is offered by the fibers of *Thymosia* Topsent (*T. guernei* Topsent, coast of France, Topsent, 1895, p. 574, pl. 22, fig. 7). This sponge, originally referred by Topsent to the Chondrosidae, is surely a horny sponge, as Lendenfeld (Zoologisches Centralblatt, vol. 3, p. 393) has suggested. Lendenfeld refers it to *Druinella*.

Subfamily STELOSPONGINAE

Stelosponginae LENDENFELD, 1889, p. 468.

Spongidae in which main fibers and connectives are generally distinguishable in the skeletal reticulum. The main fibers may be simple, but are generally more or less fascicular. Between the fascicular fibers, or between the simple main fibers in species without fascicles, the skeletal meshes are much larger than in the Eusponginae.

Genus HIRCINIA Nardo (1834).

Hircinia NARDO, 1834, p. 714.—LENDENFELD, 1889, p. 526.—GEORGE and WILSON, 1919, p. 166.

Stelosponginae with filaments in the ground substance and in which the connectives are characteristically attached to the main fibers by diverging roots which extend along the main fiber in one plane.

HIRCINIA MUTANS, new species.

Plate 44, fig. 2; plate 52, figs. 2, 4, 6, 7.

One dried specimen. Locality uncertain; no label. Sponge a cavernous mass, 280 mm. long, 150 mm. wide, and 40–100 mm. thick, which evidently had been attached and in part incrusting over one of the large surfaces. The mass is excavated by large passages, which pass through the body and are 10–20 mm. in diameter on the exposed surface, much larger over the attached surface. Dermal membrane of the attached surface pale and smooth, with only a few feeble conuli scattered here and there. On the exposed surface the conuli are strongly but variously developed, and there is a tendency for the sponge to grow out in the shape of irregular lobular elevations, between which the dermal membrane is comparatively smooth.

The character of the exposed surface with respect to the conuli is, as said, variable. The indication is that it alters with growth, and that the above mentioned lobular elevations are regions of growth. On this assumption it becomes possible to understand and describe the surface appearance. I pick out a number of conditions which I believe represent stages in growth change.

The particular surface condition, which is probably most characteristic of the species, exhibits no lobes. Instead we find elevations 3–5 mm. high, marked with several, sometimes numerous, prickles. Such elevations may be called *compound conuli.* They are mostly 10–15 mm. apart, measuring from the center of one elevation to that of the next, and are connected by prominent ridges, which divide the sponge surface into large, smooth, depressed areas. The prickles on the compound conuli may be styled *simple conuli.* Similar ones are found here and there on the ridges connecting the compound conuli. The compound conulus begins as (1) a simple conulus. In proof of this we find on the ridges not only simple conuli but (2) somewhat larger, and yet similar, elevations divided at the summit into two, three, or a few prickles, all close together. As such elevations grow they move apart and become (3) the compound conuli of the characteristic surface condition. If now a compound conulus becomes a spot of active growth, it becomes (4) more or less flattened at the top, the simple conuli moving apart from one another, but remaining connected by ridges. The flat-topped compound conulus increases in size and becomes (5) a small projecting lobe bearing simple conuli about 2 mm. apart, all interconnected by ridges. Such lobes increase in size and the simple conuli shift farther apart, so that (6) a well developed lobular projection results, bearing simple, sharp conuli 1–2 mm. high, 4–5 mm. apart, interconnected by ridges. Such lobular projections, where they are well developed, are separated by depressed areas of smooth membrane, 10–15 mm. wide. Conditions (3) and (6) differ much in appearance.

A few large oscula, 10–15 mm. in diameter, are found at one end of the sponge. They lead into shallow depressions into which a number of canals debouch. The oscular depressions may, however, be absent, the several canals opening independently on the surface. The body is greatly excavated by canals, the larger of which are 4–5 mm. in diameter. The dermal membrane is filled with broken spicules and a few sand grains, constituting the usual "sand cortex." This is distinct but thin, in general 100 µ or less in thickness. In certain regions the mineral bodies are uniformly distributed through the membrane, which in such places shows no signs of the pores. But over the greater part of the surface they are aggregated to form a dense reticulum in the meshes of which there is only thin membrane quite lacking such bodies. Here and there perforating the membrane filling a mesh is found an open pore. The meshes of this cortical reticulum are about 140 µ in diameter, the intervening strands about 50 µ thick. The entire arrangement indicates that when the pores have been closed for some time the mineral bodies become uniformly distributed through the dermal membrane, but as the pores open these bodies are shifted and become concentrated between and around them. The cortical reticulum is visible to the eye.

The filaments are very abundant, about 5 µ thick, tapering to one-half that thickness at the ends, where the enlargements are spheroidal and 10–12 µ in diameter. They are unspotted. The sponge in the dried state is compressible. Color purple or purplish gray on upper surface, yellowish brown on attached surface.

Skeleton.—Main fibers and connectives are distinguishable in the peripheral part of the sponge, the main fibers terminating in the conuli. But in the interior the course of the main fibers becomes so irregular that the skeleton here is not distinctly divisible into such fibers and connectives. Doubtless the larger fibers of the interior, with fairly abundant foreign contents, represent the main fibers, but no order is distinguishable in their distribution.

The main fibers (*m. f.* in figs. 2, 4, 6, 7 of pl. 52) may be only slightly or distinctly "fascicular," in the characteristic *Hircinia*-fashion as contrasted with *Stelospongia*—that is, the "fascicular" state is here produced by the prolongation along the primitively simple main fiber of the roots of connectives, instead of by the binding together of several more or less parallel fibers into a compound fiber. (See George and Wilson, 1919, pp. 168, 171.) The originally simple, solid, main fiber is about 150 µ thick, containing abundant sand grains and spicule fragments. It may remain simple throughout the greater part of its extent, being fascicular (fenestrated would be a better word) only where the roots of connectives meet it (pl. 52, fig. 4); or the connective roots may spread along the fiber to such an extent that it becomes almost everywhere fenestrated (pl. 52, fig. 6); such fibers may attain a thickness of 300 µ, occasionally even 400 µ.

The connectives, however much they differ in detail, are characterized by the fact that they meet the main fibers by triangular expansions perforated by apertures, which represent the connective roots of some other species. I refer to these (pl. 52, figs. 2, 4, 6, 7) as fenestrated expansions. Occasionally a connective is found which meets a main fiber not by such an expansion but by a few distinct roots (fig. 4). Where the connectives are joined by cross bars, the latter (fig. 4) terminate in small fenestrated expansions. And where one connective joins another at an angle, the same kind of connection is made (fig. 4). The fibers then in general have this characteristic way of combining, instead of by roots. They are in general without, or with only very few, mineral inclusions.

The connectives however differ considerably in detail. The following types may be recognized: (*a*) They are simple, solid fibers without inclusions, 35–50 μ thick, passing from main fiber to main fiber and only sparsely interconnected (fig. 4). (*b*) Thicker connectives, apparently formed by the fusion, parallel-wise, of two or three of the thinner ones, occur, sometimes with a few inclusions (spicules) (fig. 7). (*c*) Union between simple fibers, either parallel-wise or by interconnecting bars, gives rise to fenestrated membranes, which may be quite small or plates of considerable size (figs. 2, 6, 7).

Skeleton in general is coarse and irregular, the meshes except within a fenestrated plate large, up to and over 1 mm., sometimes reaching 3 mm., in width. There are no special dermal fibers, although occasionally a connective is so far out that it happens to be included in the dermal membrane.

Holotype.—Cat. No. 21324, U.S.N.M.

Comparing this species with two of the best known *Hircinia* forms, *H. variabilis* F. E. Schulze and *H. foetida* (O. Schmidt), it may be said that the main fibers are more "fascicular" than in *H. variabilis* and the connectives more disposed to form reticular (fenestrated) membranes, but this tendency does not go so far as in *H. foetida*, where the connectives in general have this character.

HIRCINIA VARIABILIS F. E. Schulze.

Hircinia variabilis F. E. Schulze, 1879, p. 12.—Lendenfeld, 1889, p. 557.

Station D5477, one specimen having the shape of a narrow vertical plate which bears along its lateral edges cylindrical branches extending out at right angles to the plate. The branches evidently have terminal oscula, although the latter are now closed. The shape of the sponge is obviously a variant of the ramose type. Total height, 120 mm.

Conuli low and not sharp, 3–4 mm. apart. Surface marked with the usual reticulum of narrow bands, 50 μ wide and less, full of sand grains, etc., bounding rounded or angular pore areas, 85–200 μ in diameter, that are free or nearly free of foreign particles; bands of this kind radiating from each conulus. Color, silver gray.

Filaments abundant, 6 μ thick in middle region, tapering toward the pyriform terminations; unspotted.

Main fibers fascicular, in the *Hircinia* fashion, only where connectives meet them, simple elsewhere; 260–175 μ thick, filled with sand grains and sponge spicules, extending radially into the conuli, one fiber in axis of each conulus, the fiber tapering terminally; the thin dermal layer of foreign particles covering the tips of the fibers as well as the surface in general; all as in Schulze's description. Main fibers at surface of sponge 3–4 mm. apart, the interval decreasing further in.

The system of connectives varies a good deal. The component fibers may be simple and narrow, about 100 μ thick, or may combine and form flattened plates, about 300-350 μ wide in a radial direction, which are fenestrated by comparatively few and small gaps. Whatever the details be, the connectives establish between the main fibers a comparatively simple and coarse meshwork, the meshes of which are rounded and for the most part 900–350 μ in diameter. The meshes here and there are much larger, up to 3 mm. in diameter. In other places the network is closer and the meshes may run down to a diameter of 150 μ and smaller. In general, an individual connective which meets a main fiber does so by breaking up into a set of branches ("roots"), but sometimes the connection is by a fenestrated expansion of the connective or even by an unfenestrated expansion. The connectives include sand grains and spicule fragments, these more often forming only a slender core in the fiber; the foreign particles are sometimes more abundant, but even then less abundant than in the main fibers.

There are no connectives in the dermal membrane, but the most superficial connectives sometimes lie directly beneath the membrane. The detailed nature of the most superficial connectives of the reticulum is inconstant (the inconstancy perhaps associated with growth); they sometimes differ noticeably from the connectives in general in that they contain spicule fragments with almost no sand grains and the spongin is pale.

The skeleton, as will be seen from the above, conforms in general to Schulze's admirable description, but this in its bravity scarcely more than suggests the lines of variation.

As more specimens assignable to the species are examined, it becomes evident that the variations are so numerous and intricate that not much use, except locally, can be made in practical classification of the several (eight) varieties recognized by Lendenfeld, (1889).

The distribution of the species recorded by Lendenfeld is wide, including the Mediterranean, Indian Ocean, Pacific, American coast of North Atlantic, and Australian seas. Since Lendenfeld's monograph the species has been recorded for Amboina (Topsent, 1897, p. 482), Porto Rico (Wilson, 1902, p. 405), Azores (Topsent, 1904, p. 250), Chilean waters (Thiele, 1905, p. 484), Sudanese Red Sea (Row 1911, pp. 371, 372), Spanish waters (Hernandez, 1916 p. 39, 1918 p. 33, 1921 p. 2).

BIBLIOGRAPHY.

Annandale, N.

1915. Fauna of the Chilka Lake. Sponges. Memoirs, Indian Museum, vol. 5. Calcutta.

Baer, L.

1906. Silicispongien von Sansibar, Kapstadt und Papeete. Archiv für Naturgeschichte, Jahrgang 72, vol. 1. Berlin.

Bowerbank, J. S.

1864. Monograph of the British Spongiadae, vol. 1. Ray Society. London.

1866. Idem, vol. 2. Same reference.

1874. Idem, vol. 3. Same reference.

1882. Idem, vol. 4. Same reference.

1872. Contributions to a general history of the Spongiadae, parts 1–3. Proceedings, Zoological Society of London. London.

1873. Idem, parts 4–5. Same reference.

1874*b*. Idem, part 6. Same reference.

1875. Idem, part 7. Same reference.

1876. Idem, part 8. Same reference.

1873*b*. On a collection of sponges from Ceylon. Proceedings, Zoological Society of London.

Bronn, H. G.

1859. Klassen und Ordnungen des Thierreichs, vol. 1. Amorphozoa. Leipzig. (Cited from Lendenfeld, 1889, p. 13.)

Carter, H. J.

1869. Description of a Siliceous Sand-Sponge found on the South-east coast of Arabia. (*Tethya dactyloidea.*) Annals and Magazine of Natural History, ser. 4, vol. 3.

1874. Descriptions and figures of deep-sea sponges and their spicules from the Atlantic Ocean dredged up on board H. M. S. *Porcupine*, chiefly in 1869. Annals and Magazine of Natural History, ser. 4, vol. 14.

1879. Contributions to our Knowledge of the Spongida. Same reference, ser. 5, vol. 3.

1881. Supplementary report on specimens dredged up from the Gulf of Manaar. Same reference, ser. 5, vol. 7.

1881*b*. Contributions to our knowledge of the Spongida. Order II. Ceratina. Same reference, ser. 5, vol. 8.

1882. New sponges, observations on old .ones, and a proposed new group. Same reference, ser. 5, vol. 10.

1887. Report on the marine sponges, chiefly from King Island in the Mergui Archipelago, etc. Journal, Linnean Society (Zoology), vol. 21.

Crozier, Blanche B.

1918. Bermudan species of Donatia (Tethya). Annals and Magazine of Natural History, ser. 9, vol. 1.

Delage, Y., and Hérouard, E.

1899. Traité de Zoologie Concrète. Vol. 2, pt. 1. Mesozoaires. Spongiaires. Paris.

DENDY, A.

1887. The sponge fauna of Madras. Annals and Magazine of Natural History, ser. 5, vol. 20.

1889. Report on a second collection of sponges from the Gulf of Manaar. Annals and Magazine of Natural History, ser. 6, vol. 3.

1890. Observations on the West Indian chalinine sponges, with descriptions of new species. Transactions, Zoological Society of London, vol. 12.

1894. Catalogue of noncalcareous sponges collected by J. Bracebridge Wilson, Esq., M. A., in the neighborhood of Port Phillip Heads, part 1. Proceedings, Royal Society Victoria, vol. 7. Melbourne.

1895. Idem, part 2. Same reference, vol. 8.

1896. Idem, part 3. Same reference, vol. 9.

1905. Report on the sponges collected by Professor Herdman at Ceylon in 1902. In: Herdman Rep. Pearl Oyster Fisheries, pt. 3. London.

1916. Report on the Homosclerophora and Astrotetraxonida collected by H. M. S. *Sealark* in the Indian Ocean. Transactions, Linnean Society of London. Ser. 2. Zoology, vol. 17, pt. 2.

1916*b*. Report on the noncalcareous sponges collected by Mr. James Hornell at Okhamandal in Kattiawar in 1905–6. Williams and Norgate, London.

1921. The tetraxonid sponge spicule—a study in evolution. Acta Zoologica (separate).

1921*b*. Report on the Sigmatotetraxonida collected by H. M. S. *Sealark* in the Indian Ocean. Transactions, Linnean Society of London, vol. 18, pt. 1.

EHLERS, E.

1870. Die Esperschen Spongien in den Zoologischen Sammlungen der k. Universitäts. Universitäts-Programm. Erlangen. (Cited from Lendenfeld, 1888, p. 25.)

GEORGE, W. C. and WILSON, H. V.

1919. Sponges of Beaufort (N. C.) harbor and vicinity. Bulletin, U. S. Bureau of Fisheries, vol. 36 for 1917–18. Washington.

GRANT, R. E.

1826. Observations and experiments on the structure and functions of the sponge. Edinburgh Philosophical Journal. Vol. 14. (Cited from Vosmaer, 1887, pp. 47, 51, 203 and Johnston, 1842, p. 51).

1861. Tabular view of the primary divisions of the animal kingdom. London. (Cited from Bowerbank, 1864, p. 154.)

GRAY, J. E.

1867. Notes on the Arrangement of Sponges with the description of some new Genera. Proceedings Zoological Society of London.

1868. Observations on Sponges and on their Arrangement and Nomenclature. Annals and Magazine of Natural History, vol. 1.

1868*b*. Note on *Theonella*, a new Genus of Coralloid Sponges from Formosa. Proceedings, Zoological Society of London.

1869. Note on *Ianthella*, a new Genus of Keratose Sponges. Same reference.

HALLMANN, E. F.

1912. Zoological results of the fishing experiments carried out by the F. I. S. *Endeavour*, 1909–10 (H. C. Dannevig, Commonwealth Director of Fisheries). Part 2. Report on the sponges obtained by the F. I. S. *Endeavour* on the coasts of New South Wales, Victoria, South Australia, Queensland, and Tasmania. Part 1. Sydney.

HALLMANN, E. F.—Continued.

1916. A Revision of the genera with microscleres included, or provisionally included, in the family Axinellidae; with descriptions of some Australian species. Parts I, II. Proceedings Linnaean Society of New South Wales. Vol. 41. Sydney, New South Wales.

1917. Idem, pt. 3. Same reference.

HENTSCHEL, E.

1909. Die Fauna Südwest-Australiens. Tetraxonida, Part 1. Fischer, Jena.

1911. Idem. Part 2. Fischer, Jena.

1911*b*. Ueber den Ursprung der Microsclere der Desmacidoniden. Zoologischer Anzeiger, vol. 38, p. 148.

1912. Kiesel-und Hornschwämme der Aru-und Kei-Inseln. Abhandlungen der Senckenbergischen naturforschenden Gesellschaft, vol. 34. Frankfurt.

1913. Ueber einen Fall von Orthogenese bei den Spongien. Zoologischer Anzeiger, vol. 42, p. 255.

1913*b*. Ueber die Anwendung der funktionalen Betrachtungsweise auf die biologische Systematik. Biologisches Centralblatt, vol. 33, p. 644.

1914. Monaxone Kieselschwämme und Hornschwämme der deutschen Südpolar Expedition 1901–1903. Reimer, Berlin.

1914*b*. Die Spiculationsmerkmale der monaxonen Kieselschwämme. Mitteilungen aus dem Naturhistorischen Museum, vol. 31. Hamburg.

HERNANDEZ, F. F.

1912. Notas sobre algunas esponjas de Santander. Dissertation for the doctorate in the Central University of Spain. Madrid.

1914. Esponjas del Cantábrico. Parte segunda. Trabajos del Museo Nacional de Ciencias Naturales. Serie Zoologica, Núm. 17. Madrid.

1916. Fauna del Mediterraneo occidental. Esponjas Españolas. Same reference, Núm. 27.

1918. Esponjas del Litoral de Asturias. Same reference. Núm. 36.

1919. Descripción de tres esponjas nuevas del litoral Español. Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales, de Madrid, vol. 16. Madrid.

1921. Esponjas recogidas en la campaña preliminar del "Giralda." Boletin de Pescas, 1921. Madrid.

HYATT, A.

1875. Revision of the North American Poriferae; with remarks upon foreign species. Part I. Memoirs, Boston Society of Natural History. Vol. 2. Boston.

1877. Idem., Part 2. Same reference.

JOHNSTON, G.

1842. A history of British sponges and lithophytes. W. H. Lizars, Edinburgh.

KELLER, O.

1880. Neue Coelenteraten aus dem Golf von Neapel. Archiv für mikroskopischen Anatomie, vol. 18.

1889–91. Spongien-fauna des rothen Meeres, I and II. Zeitschrift für wissenschaftliche Zoologie, vols. 48 and 52.

KIESCHNICK, O.

1900. Kieselschwämme von Amboina. Semon, Zoologische Forschungsreisen in Australien und dem Malayischen Archipel, vol. 5. Jena.

KIRKPATRICK, R.

1900. Description of sponges from Funafuti. Annals and Magazine of Natural History, ser. 7, vol. 6.

1902. Marine Investigations in South Africa (Department of Agriculture, Cape of Good Hope). Descriptions of South African sponges. Government Printers, Cape Town.

1902*b*. Idem. Descriptions of South African Sponges, pt. 2. Same reference.

1903. Idem. Descriptions of South African Sponges, pt. 3. Same reference.

1905. On the oscules of Cinachyra. Annals and Magazine of Natural History, ser. 7, vol. 16.

1908. National Antarctic Expedition. Natural History, vol. 4. Porifera Tetraxonida. British Museum. London.

1911. On Merlia normani, a sponge with a siliceous and calcareous skeleton. Quarterly Journal of Microscopical Science. vol. 56.

LAMBE, L. M.

1893. On some sponges from the Pacific coast of Canada and Behring Sea. Transactions, Royal Society of Canada, vol. 10, sec. 4. Ottawa.

LEBWOHL, F.

1914. Japanische Tetraxonida. Journal of the College of Science, Imperial University of Tokyo, vol. 35, articles 2 and 5. Tokyo.

LENDENFELD, R. VON.

1885. Die Verwandtschaftsverhältnisse der Myxospongien. Zoologischer Anzeiger, vol. 8.

1887. Die Chalinien des australischen Gebietes. Zoologische Jahrbücher, vol. 2. Jena.

1888. Descriptive catalogue of the sponges in the Australian Museum, Sydney. Publication of the Australian Museum.

1889. A monograph of the horny sponges. Trübner and Co., London. Published for the Royal Society.

1894. Die Tetractinelliden der Adria. Schriften der mathematisch-naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, vol. 61. Wien.

1894*b*. Die Spongien der Adria. II. Die Hexaceratina. Zeitschrift für wissenschaftliche Zoologie, vol. 54.

1896. Die Clavulina der Adria. Abhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Deutschen Akademie der Naturforscher, vol. 69. Halle.

1897. Spongien von Sansibar. Abhandlungen der senckenbergischen naturforschenden Gesellschaft, vol. 21. Frankfurt.

1903. Das Tierreich, 19 Lieferung. Tetraxonia. Friedländer und Sohn. Berlin.

1906. Wissenschaftliche Ergebnisse der deutschen Tief-see Expedition, vol. 11. Die Tetraxonia. Fischer, Jena.

1907. Deutsche Süd-polar Expedition 1901–1903, vol. 9. Zoologie, I. Tetraxonia. Berlin.

1910. Reports on the scientific results of the expedition to the eastern tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer *Albatross*, from October, 1904, to March, 1905. The Sponges. 1. The Geodidae. Memoirs, Museum of Comparative Zoölogy, vol. 41, No. 1. Cambridge, Mass.

1910*b*. Idem. The Sponges. 2. The Erylidae. Same reference, vol. 41, No. 2.

LINDGREN, N. G.
1898. Beitrag zur Kenntnis der Spongienfauna des malayischen Archipels und der chineschen Meere. Zoologische Jahrbücher, Abtheilung für Systematik, Geographie und Biologie der Thiere, vol. 11. Jena.

LUNDBECK, W.
1902. The Danish Ingolf-Expedition, vol. 6, pt. 1. Porifera (pt. 1). Published * * * by the direction of the Zoological Museum of the University. Copenhagen.
1905. Idem. Porifera (pt. 2). Same reference.
1910. Idem. Porifera (pt. 3). Same reference.

MEREJKOWSKI, C.
1878. Études sur les Éponges de la Mer Blanche. Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg, VII^e serie, vol. 26. St. Pétersbourg.

MONTAGU, G.
1818. An Essay on Sponges, with descriptions of all the species that have been discovered on the coast of Great Britain,. Memoirs, Wernerian Society, vol. 2. Edinburgh. (Cited from Lendenfeld, 1889, p. 54.)

NARDO, G. D.
1833–34. Classification der Schwämme. Isis (Oken), 1833, p. 519; 1834, p. 714. (Cited from Vosmaer, 1887, pp. 11, 51, 202).

PALLAS, P. S.
1766. Elenchus Zoophytorum. (Cited from Lendenfeld, 1888, p. 23.)

POLEJAEFF, N.
1884. Report on the scientific results of the voyage of H. M. S. *Challenger* during the years 1873–76. Zoology, vol. 11, pt. 31. Report on the Keratosa. Edinburgh.

RIDLEY, S. O.
1884. Spongiida. In: Report on the Zoological collections made in the Indo-Pacific Ocean during the voyage of H. M. S. *Alert*, 1881–82. British Museum. London.

RIDLEY, S. O., and DENDY, A.
1887. Report on the Monaxonida collected by H. M. S. *Challenger*. In: Report on the scientific results of the voyage of H. M. S. *Challenger* during the years 1873–1876. Zoology, vol. 20, pt. 59. Edinburgh.

ROW, R. W. H.
1911. Reports on the marine biology of the Sudanese Red Sea, XIX. Report on the sponges collected by Mr. Cyril Crossland in 1904–5, Part 2. Noncalcarea. Journal, Linnean Society. Zoology, vol. 31. London.

SARS, G. O.
1872. On some remarkable forms of animal life from the great deeps of the Norwegian coast. Part 1. Partly from the posthumous papers of Michael Sars. University Program. Christiania. (Cited from Lendenfeld, 1889, p. 61.)

SCHMIDT, O.
1862. Die Spongien des adriatischen Meeres. Leipzig.
1864. Supplement der Spongien des adriatischen Meeres. Leipzig.
1866. Zweites Supplement der Spongien des adriatischen Meeres. Leipzig.
1868. Die Spongien der Küste von Algier. Leipzig.
1870. Grundzüge einer Spongienfauna des atlantischen Gebietes. Leipzig.

SCHMIDT, O.—Continued.

1879–1880. Die Spongien des Meerbusen von Mexico. I. II. Jena.

1885. Entstehung neuer Arten durch Verfall und Schwund älterer Merkmale. Zeitschrift für wissenschaftliche Zoologie, vol. 42. Leipzig

SCHULZE, F. E.

1877. Untersuchungen über den Bau und die Entwicklung der Spongien. Die Familie der Chondrosidae. Zeitschrift für wissenschaftliche Zoologie, vol. 29. Leipzig.

1878. Idem. Die Familie der Aplysinidae. Same reference, vol. 30.

1879. Idem. Die Gattung Hircinia Nardo und Oligoceras n. g. Same reference, vol. 33.

1879*b*. Idem. Die Gattung Spongelia. Same reference, vol. 32.

1880. Idem. Die Plakiniden. Same reference, vol. 34.

1887. Report on the Hexactinellida collected by H. M. S. *Challenger*. In Report on the scientific results of the voyage of H. M. S. *Challenger* during the years 1873–76. Zoology, vol. 21. Edinburgh.

SOLLAS, IGERNA.

1902. On the sponges collected during the "Skeat Expedition" to the Malay Peninsula, 1899–1900. Proceedings, Zoological Society of London. 1902, pt. 2.

1903. On Haddonella topsenti, gen. et sp. n., the structure and development of its pithed fibers. Annals and Magazine of Natural History. Ser. 7, vol. 12.

SOLLAS, W. J.

1880. The Sponge-fauna of Norway: a report on the Rev. A. M. Norman's Collection of Sponges from the Norwegian coast. Annals and Magazine of Natural History, ser. 5. vol. 5.

1888. Report on the Tetractinellida collected by H. M. S. *Challenger*. In: Report on the scientific results of the voyage of H. M. S. *Challenger* during the years 1873–1876. Zoology, vol. 25. Edinburgh.

1889. On the geodine genera Synops Vosm. and Sidonops. A correction. Proceedings, Royal Dublin Society, vol. 6, pt. 5.

STEPHENS, JANE.

1912. Clare Island Survey. Part 59. Marine Porifera. Proceedings, Royal Irish Academy, vol. 31. Dublin.

1915. Atlantic Sponges collected by the Scottish National Antarctic Expedition. Transactions, Royal Society of Edinburgh, vol. 50, pt. 2. Edinburgh.

1915*b*. Fisheries, Ireland, Scientific Investigations, 1914, IV. Sponges of the coasts of Ireland. I. London.

1917. Report on the sponges collected off the coast of Ireland by the dredging expeditions of the Royal Irish Academy and the Royal Dublin Society. Proceedings, Royal Irish Academy, vol. 34, sec. B. Dublin.

1921. Fisheries, Ireland, Scientific Investigations, 1920, II. Sponges of the coasts of Ireland. II. Dublin.

STEWART, C.

1870. On a new Sponge, *Tethyopsis columnifer*. Quarterly Journal of Microscopical Science, vol. 10.

THIELE, J.

1898. Studien über pazifische Spongien. Zoologica, Heft 24. Stuttgart.

1899. Idem, pt. 2. Same reference, Heft 24, pt. 2.

1899*b*. Ueber Crambe crambe (O. Schmidt). Archiv für Naturgeschichte. Jahrgang 65.

1900. Kieselschwämme von Ternate. I. Abhandlungen der Senckenbergischen naturforschenden Gesellschaft, vol. 25, Heft 1. Frankfurt.

1903. Idem. II. Same reference, vol. 25, Heft 4.

1905. Die Kiesel-und Hornschwämme der Sammlung Plate. Zoologische Jahrbücher, Supplement 6, vol. 3. Jena.

1921. Ueber das System der Demospongien. Zoologischer Anzeiger, vol. 53.

THOMPSON, (SIR) C. WYVILLE.

1873. The Depths of the sea. Macmillan and Co. New York and London.

TOPSENT, E.

1887. Contribution à l'étude des Clionides. Archives de Zoologie expérimentale et générale, ser. 2, vol. 5 *bis*. Paris.

1892. Résultats des campagnes scientifiques * * * par Albert I^{re}, Prince Souverain de Monaco. Fasc. II. Contribution à l'étude des spongiaires de l'Atlantique Nord. Monaco.

1892*b*. Éponges de la Mer Rouge. Mémoires de la Société Zoologique de France, vol. 5. Paris.

1892*c*. Diagnoses d'éponges nouvelles de la Méditerranée et plus particulièrement de Banyuls. Archives de Zoologie expérimentale et générale, ser. 2, vol. 10. Notes et revue.

1893. Note sur quelques éponges du Golfe de Tadjoura recueillies par M. le Dr. L. Faurot. Bulletin, Société Zoologique de France, vol. 18.

1893*b*. Nouvelle série de diagnoses d'éponges de Roscoff et de Banyuls. Archives de Zoologie expérimentale et générale, ser. 3, vol. 1. Notes et revue.

1894. Étude sur la faune des spongiaires du Pas-de-Calais suivie d'une application de la nomenclature actuelle à la monographie de Bowerbank. Revue biologique du Nord de la France, vol. 7.

1894*b*. Étude monographique des Spongiaires de France. I. Tetractinellida. Archives de Zoologie expérimentale et générale, ser. 3, vol. 2. Paris.

1894*c*. Une réforme dans la classification des Halichondrina. Mémoires, Société Zoologique de France, vol. 7. Paris.

1895. Étude monographique des Spongiaires de France. II. Carnosa. Archives de Zoologie expérimentale et générale, ser. 3, vol. 3. Paris.

1896. Matériaux pour servir à l'étude de la faune des Spongiaires de France. Mémoires, Société Zoologique de France, vol. 9. Paris.

1897. Spongiaires de la Baie d'Amboine. Voyage de MM. M. Bedot et C. Pictet dans l'archipel Malais. Revue suisse de zoologie, vol. 4. Genève.

1897*b*. Sur le genre Halicnemia Bowerbank. Mémoires, Société Zoologique de France, vol. 10.

1898. Introduction a l'étude monographique des monaxonides de France. Classification des Hadromerina. Archives de Zoologie expérimentale et générale, ser. 3, vol. 6. Paris.

TOPSENT, E.—Continued.

1898*b*. Éponges nouvelles des Açores (Première Série). Mémoires, Société Zoologique de France, vol. 11. Paris.

1900. Étude monographique des Spongiaires de France. III. Monaxonida (Hadromerina). Archives de Zoologie expérimentale et générale, ser. 3, vol. 8.

1901. Expedition Antarctique Belge. Résultats du voyage du S. Y. Belgica en 1897–1898–1899. Spongiaires. Anvers.

1901*b*. Éponges de la Calle. Archives de Zoologie expérimentale et générale, ser. 3, vol. 9. Paris.

1902. Sur l'orientation des Crinorhiza. Comptes rendus des séances de l'Academie des sciences. Paris.

1902*b*. Les Asterostreptidae. Bulletin, Société scientifique et médicale de l'Ouest, vol. 11, no. 2. Rennes.

1904. Résultats des campagnes scientifiques * * * par Albert I^{re}, Prince Souverain de Monaco. Fasc. 25. Spongiaires des Açores. Monaco.

1905. Étude sur les Dendroceratida. Archives de Zoologie expérimentale et générale, ser. 4, vol. 3. Notes et revue. Paris.

1906. Éponges recueillies par M. Ch. Gravier dans la Mer Rouge. Bulletin du Muséum d'histoire naturelle. 1906, No. 7. Paris.

1906*b*. Les Clavulides purpurines. Same reference, 1906, No. 7.

1907. Cliona purpurea Hck. n'est pas une Clionide. Archives de Zoologie expérimentale et générale, ser. 4, vol. 7. Notes et revue. Paris.

1908. Sur une variété de Clionopsis platei Thiele. Bulletin de l'Institut Océanographique, No. 120. Monaco.

1911. Sur les affinités des Halichondria et la classification des Halichondrines d'après leurs formes larvaires. Archives de Zoologie expérimentale et générale, ser. 5, vol. 7. Notes et revue. Paris.

1911*b*. Sur une magnifique Geodia megastrella Carter du Muséum de La Rochelle. Imprimerie E. Martin. La Rochelle.

1912. Sur une grande Tedania abyssale des Açores (Tedania phacellina, n. sp.). Bulletin de l'Institut Océanographique, No. 252. Monaco.

1913. Spongiaires de l'expédition antarctique nationale écossaise. Transactions, Royal Society of Edinburgh, vol. 49, pt. 3. Edinburgh.

1913*b*. Résultats des campagnes scientifiques * * * par Albert I^{re}, Prince Souverain de Monaco. Fasc. 45. Spongiaires provenant des compagnes scientifiques de la Princesse-Alice dans les Mers du Nord. Monaco.

1915. Spongiaires recuellies par la "Scotia" dans l'Antarctique (1903–1904). Supplement. Transactions, Royal Society of Edinburgh, vol. 51, pt. 1. Edinburgh.

1916. Diagnoses d'éponges recueillies dans l'Antarctique par le Pourquoi-Pas? Bulletin du Muséum d'histoire naturelle, 1916, No. 3. Paris.

1917. Deuxième expédition antarctique française (1908–1910) * * * Documents scientifiques. Spongiaires. Masson et Cie. Paris.

1918. Éponges de San Thomé. Essai sur les genres Spirastrella, Donatia et Chondrilla. Archives de Zoologie expérimentale et générale, vol. 57, fasc. 6. Paris.

1919. Notes sur les genres Semisuberites et Hemiasterella. Bulletin de l'Institut Océanographique. No. 359. Monaco.

1920. Caractères et affinités des Thoosa Hanc. et des Alectona Cart. Considerations sur leurs germes à armure. Bulletin, Société Zoologique de France, vol. 45. Paris.

TOPSENT, E.—Continued.

1920*b*. Tethya aurantium (Pallas) et les Tethya de Lamarck. Bulletin du Muséum d'histoire naturelle. 1920, No. 7. Paris.

1920*c*. Sur quelques éponges du cabinet de J. Hermann décrites et figurées par Esper en 1794. Bulletin, Société Zoologique de France, vol. 45. Paris.

1920*d*. Spongiaires du Musée zoologique de Strasbourg. Monaxonides. Bulletin de l'Institut Océanographique. No. 381.

1922. Les mégasclères polytylotes des Monaxonides et la parenté des Latrunculiines. Bulletin de l'Institut Océanographique. No. 415. Monaco.

VERRILL, A. E.

1907. The Bermuda Islands. Part V.—Characteristic Life of the Bermuda Coral Reefs. Porifera: Sponges. Transactions, Academy Arts and Sciences, New Haven, Conn., vol. 12, pp. 330–344.

VOSMAER, G. C. J.

1882. Report on the sponges dredged up in the Arctic Sea by the "Willem Barents" in the years 1878 and 1879. Niederl. Archiv für Zool. Suppl. I.

1885. The sponges of the "Willem Barents" expedition, 1880 and 1881. Bijdragen tot de dierkunde, Aflevering 12. Amsterdam.

1887. Bronn: Die Klassen und Ordnungen des Thier-Reichs, vol. 2. Spongien. Leipzig and Heidelberg.

1902. On the shape of some siliceous spicules of sponges. Proceedings, Koninklijke Akademie van Wetenschappen te Amsterdam, 1902. Amsterdam.

1908. Poterion a boring sponge. Same reference.

1909. On the spinispirae of *Spirastrella bistellata* (O. S.) Ldf. Same reference.

1911. Siboga-Expeditie. The Porifera of the Siboga Expedition, II. The genus Spirastrella. Brill, Leiden.

1912. On the distinction between the genera Axinella, Phakellia, Acanthella a. o. Zoologische Jahrbücher, Supplement 15, vol. 1. Jena.

1916. On the occurrence of desmas or desmoids in *Hymeniacidon sanguinea*. Proceedings, Koninklijke Akademie van Wetenschappen te Amsterdam. Amsterdam.

VOSMAER, G. C. J., and PEKELHARING, C. A.

1898. Observations on sponges. Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam (Tweede sectie), pt. 6. Amsterdam.

VOSMAER, G. C. J., and VERNHOUT, J. H.

1902. Siboga-Expeditie. The Porifera of the Siboga Expedition, I. The genus Placospongia. Brill, Leiden.

WELTNER, W.

1882. Beiträge zur Kenntniss der Spongien. Inaug.-Dissertation. Freiburg.

WILSON, H. V.

1902. The sponges collected in Porto Rico in 1899. Bulletin, U. S. Commission of Fish and Fisheries, vol. 20 for 1900, pt. 2. Washington.

1904. Reports on the exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands * * * during 1891 * * *. The Sponges. Memoirs, Museum of Comparative Zoölogy, vol. 30. Cambridge, Mass.

WILSON, H. V.—Continued.

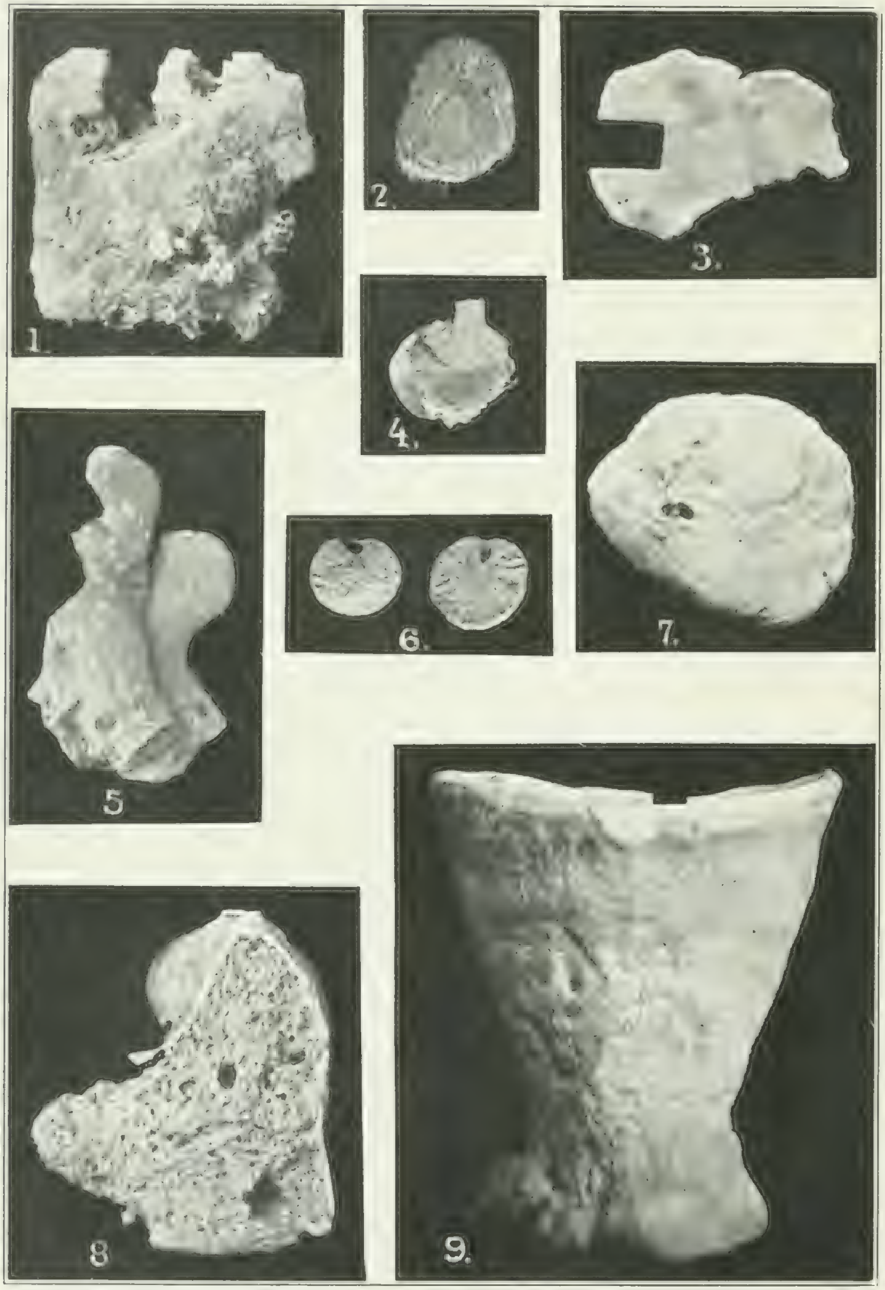
1919. In regard to species and sponges. The Scientific Monthly for 1919, p. 349.

1919*b*. On some generic distinctions in sponges. Journal, Elisha Mitchell Scientific Society, vol. 35, p. 15. Chapel Hill, N. C.

1920. A remarkable form of skeletal element in the lithistid sponges. (A case of analogical resemblance.) Same reference, vol. 36, p. 54.

WRIGHT, E. P.

1881. On a new genus and species of Sponge (*Alemo seychellensis*) with supposed heteromorphic zooids. Transactions, Royal Irish Academy, vol. 28.



Silicious and Horny Sponges from Philippine Waters

For explanation of plate see page 607

EXPLANATION OF PLATES.

(Plates 37–44 from photographs; plates 45–52 from drawings. In reproduction the photographs have been reduced to about two-thirds the original size, the drawings have been reduced to about one-half the original size.)

PLATE 37.

FIG. 1. *Sphinctrella bifacialis.* Upper surface of sponge showing cloacal depression into which oscula open. Two pieces have been cut out on far side of cloaca. On the near side the sponge is attached to a coralline mass. ×5/8.

2. *Stelletta radicifera.* Bisected sponge. ×1.
3. *Poecillastra ciliata.* Upper and lateral margins represent the free edge of the (lamellate) sponge. A piece has been excised. ×3/4.
4. *Tethyopsis dubia.* Bisected sponge. ×1.
5. *Geodia sparsa.* Sponge from the side. ×5/8.
6. *Myriastra clavosa* (Ridley). Two bisected sponges. In the one to the right, the cloaca extends in radially; in the one to the left, it extends in obliquely. ×1.
7. *Characella abbreviata.* Upper surface showing cloaca, opening into which are seen two oscula. ×3/4.
8. *Erylus cornutus.* Bisected sponge. Cloacal surface above; natural outer surface to the right; left half of sponge badly damaged. ×5/8.
9. *Geodia philippinensis.* Sponge from the side. ×1/7.

PLATE 38.

FIG. 1. *Geodia japonica* (Sollas), var. *spherulifera*. From above, showing cloaca. ×⅔.

2. *Sidonops microspinosa*. Bisected sponge. ×½.

3. *Geodinella spherastrosa*. Left piece showing upper surface with oscular elevations; right piece showing latero-inferior surface passing above into upper surface. ×1.

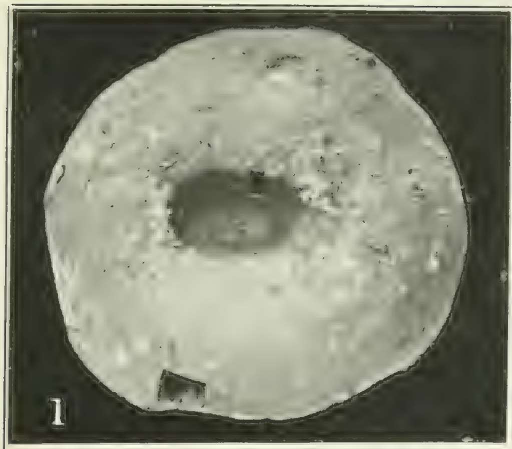
4. *Asteropus simplex* (Carter). From the side. The incrusting *Gellius* which covered the whole upper part of body has been partly cut away. ×1.

5. *Rhizaxinella nuda*. Bisected sponge, showing axial skeletal bundle. ×¾.

6. *Jaspis serpentina*. Obliquely from the side, showing upper cup-like cavity. ×½.

7. *Trichostemma straticulatum*. Oscular surfaces of two specimens. ×1.

8. *Spongosorites suluensis*. Oscular surface. ×1.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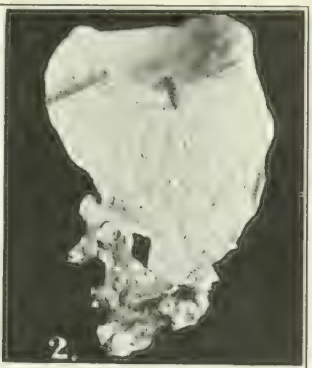
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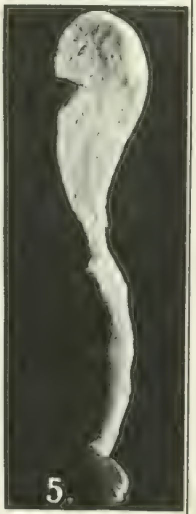
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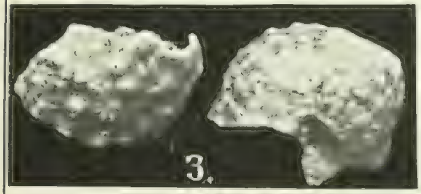
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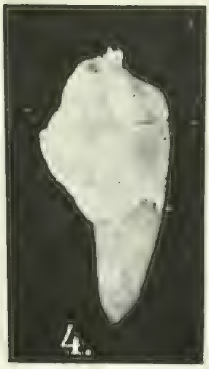
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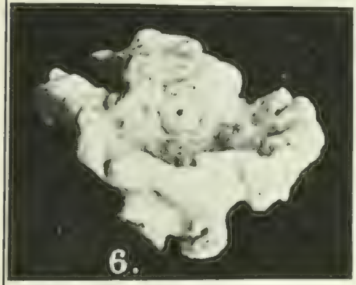
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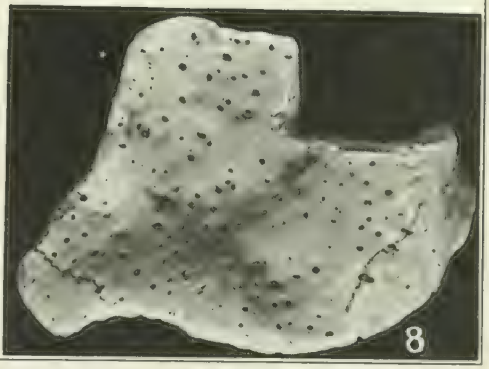
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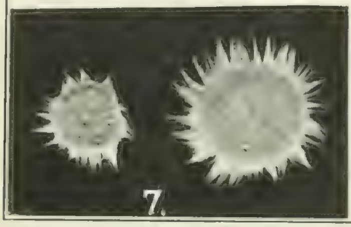
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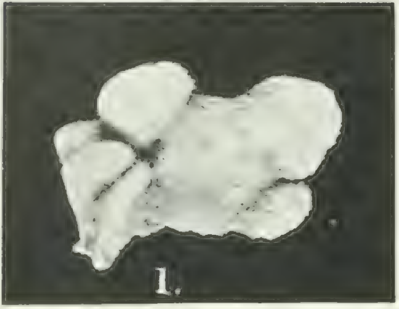
SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 608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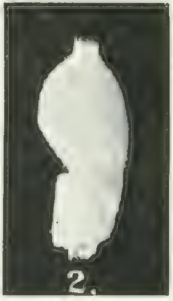
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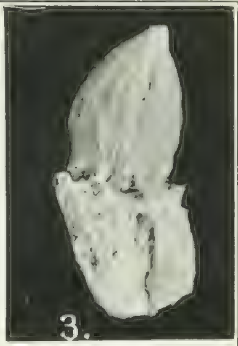
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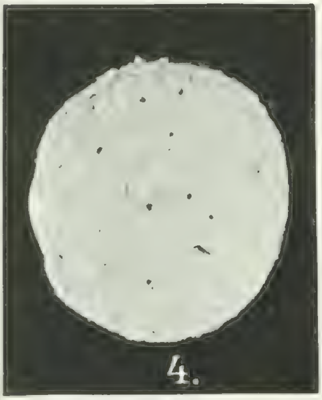
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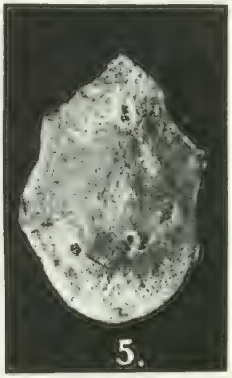
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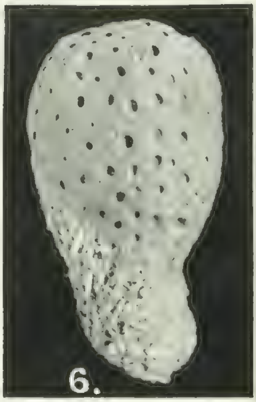
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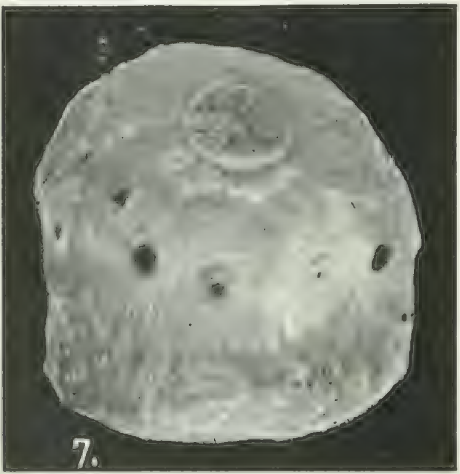
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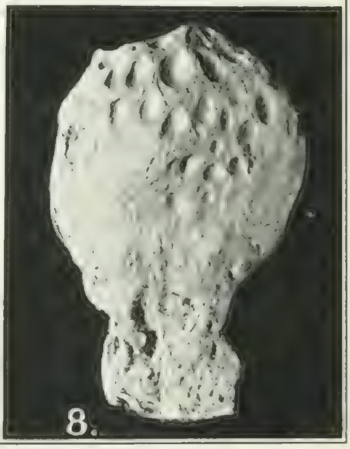
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SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 509

PLATE 39.

FIG. 1. *Tuberella ciliata.* Latero-superior surface. ×$\frac{3}{4}$.

2. *Tetilla ciliata.* From the side. ×1.

3. *Tetilla spinosa.* From the side. ×$\frac{1}{2}$.

4. *Tetilla (Cinachyrella) clavigera* (Hentschel). ×$\frac{3}{4}$.

5. *Tetilla (Cinachyrella) crustata.* Upper surface; apertures of poriferous pits on this surface and at margin. ×$\frac{3}{4}$.

6. *Tetilla (Cinachyrella) paterifera.* From the side; apertures of pits more or less contracted and therefore with sharp margin. ×$\frac{3}{4}$.

7. *Tetilla (Cinachyrella) crustata*, var. *patellae-spinosae.* Obliquely from the side, showing a spinous (oscular) area and a number of poriferous pits. ×$\frac{3}{4}$.

8. *Tetilla (Cinachyrella) paterifera.* From the side; poriferous pits wide open. ×$\frac{3}{4}$.

PLATE 40.

FIG. 1. *Craniella simillima* (Bowerbank). From the side, showing conules above, papillae below. ×¾.

2. *Paratetilla arcifera.* From the side, showing two poriferous pits; at the right, the body is covered with shelly incrusting material; some of the smooth under surface appears. ×1.

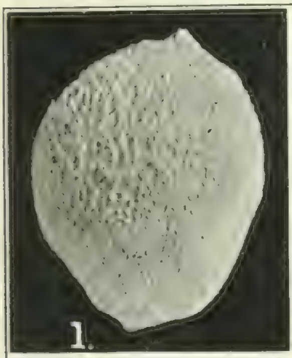
3. *Gellius varius*, var. *fibrosa.* Three pieces of the same specimen, showing very flattened, moderately flattened, and subcylindrical shapes; piece to the right is the end of a branch. ×⅓.

4. *Gellius angulatus*, var. *vasiformis.* From the side. ×½.

5. *Petrosia testudinaria*, var. *fistulophora.* Specimen from station 5253, from the side; specimen represents about a fourth of the whole sponge. ×¼.

6. *Petrosia testudinaria.* From the side. ×¼.

7. *Strongylophora corticata.* From the side. ×½



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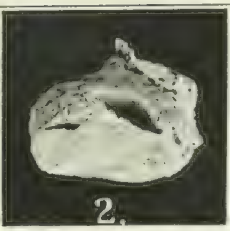

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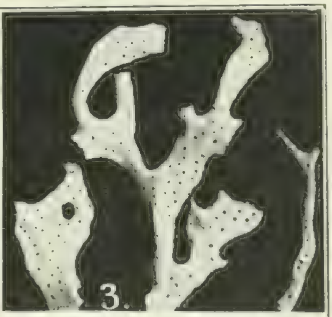

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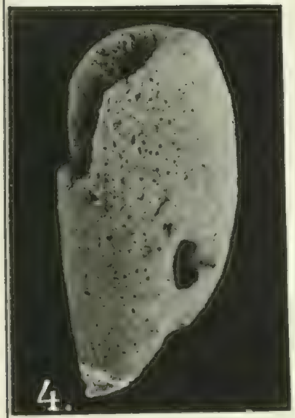

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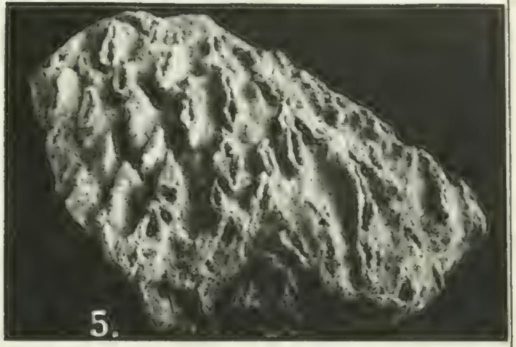

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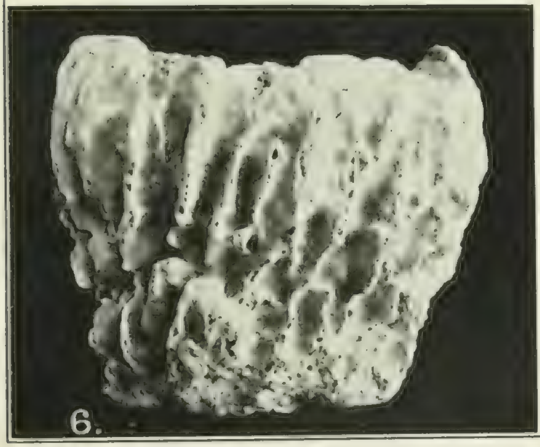

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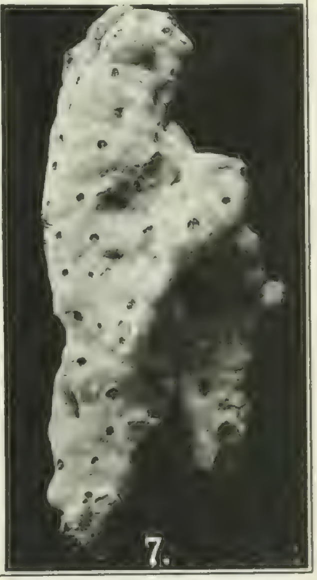
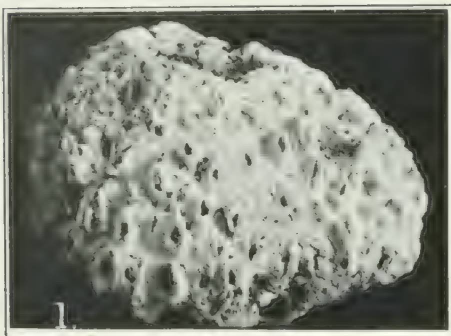


7.

Silicious and Horny Sponges from Philippine Waters

For explanation of plate see page 510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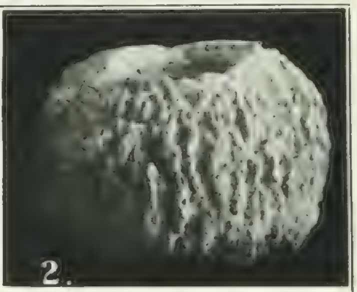
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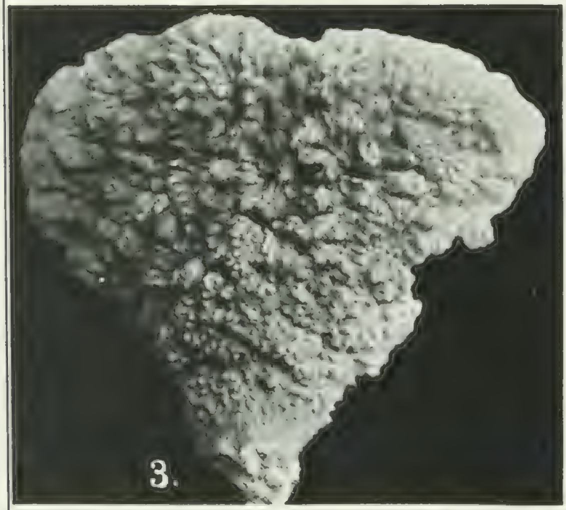
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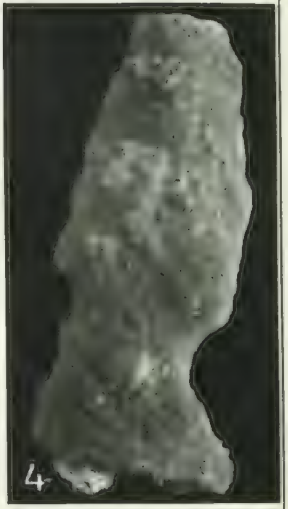
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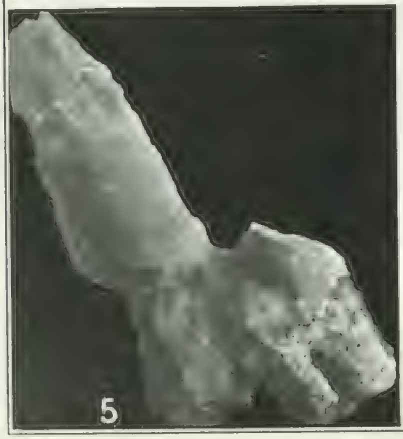
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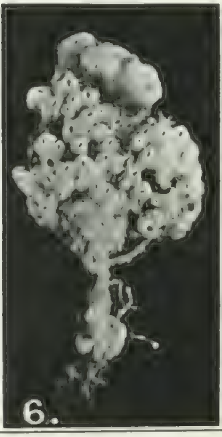
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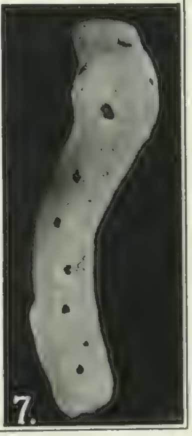

7.

SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 511

PLATE 41.

FIG. 1. *Petrosia testudinaria*, var. *fistulophora*. Specimen, entire, from station 5254; from the side. $\times \frac{1}{4}$.

2. *Petrosia testudinaria*, var. *fistulophora*. Specimen, entire, from station 5249; from the side. $\times \frac{1}{4}$.

3. *Petrosia lignosa*. Side view of the vase-shaped sponge. $\times \frac{1}{7}$.

4. *Petrosia lignosa*, var. *plana*. From the side. $\times \frac{1}{4}$.

5. *Petrosia lignosa*, var. *plana*. From the side. $\times \frac{1}{4}$.

6. *Petrosia crustata* and *Discodermia emarginata* Dendy. The *Petrosia* covers a *Gorgonia*-like alcyonarian and everywhere shows the apertures of the little depressions which lodge barnacles. The *Discodermia* is the compact mass at the summit. $\times \frac{1}{2}$.

7. *Petrosia similis*, var. *granulosa*. Sponge seen from one of the narrower sides; oscula in a row. $\times \frac{1}{2}$.

PLATE 42.

FIG. 1. *Dactylochalina exigua*, var. *samarensis*. Part of a mass. The shoots composing it have been somewhat separated and spread out. ×$\frac{2}{3}$.

2. *Siphonochalina fascigera* Hentschel. Part of specimen from Tomahu Island; showing smooth and conulose types of surface. ×$\frac{1}{3}$.

3. *Phloeodictyon cagayanense*. From the side, with incrusting alcyonarian below. ×1.

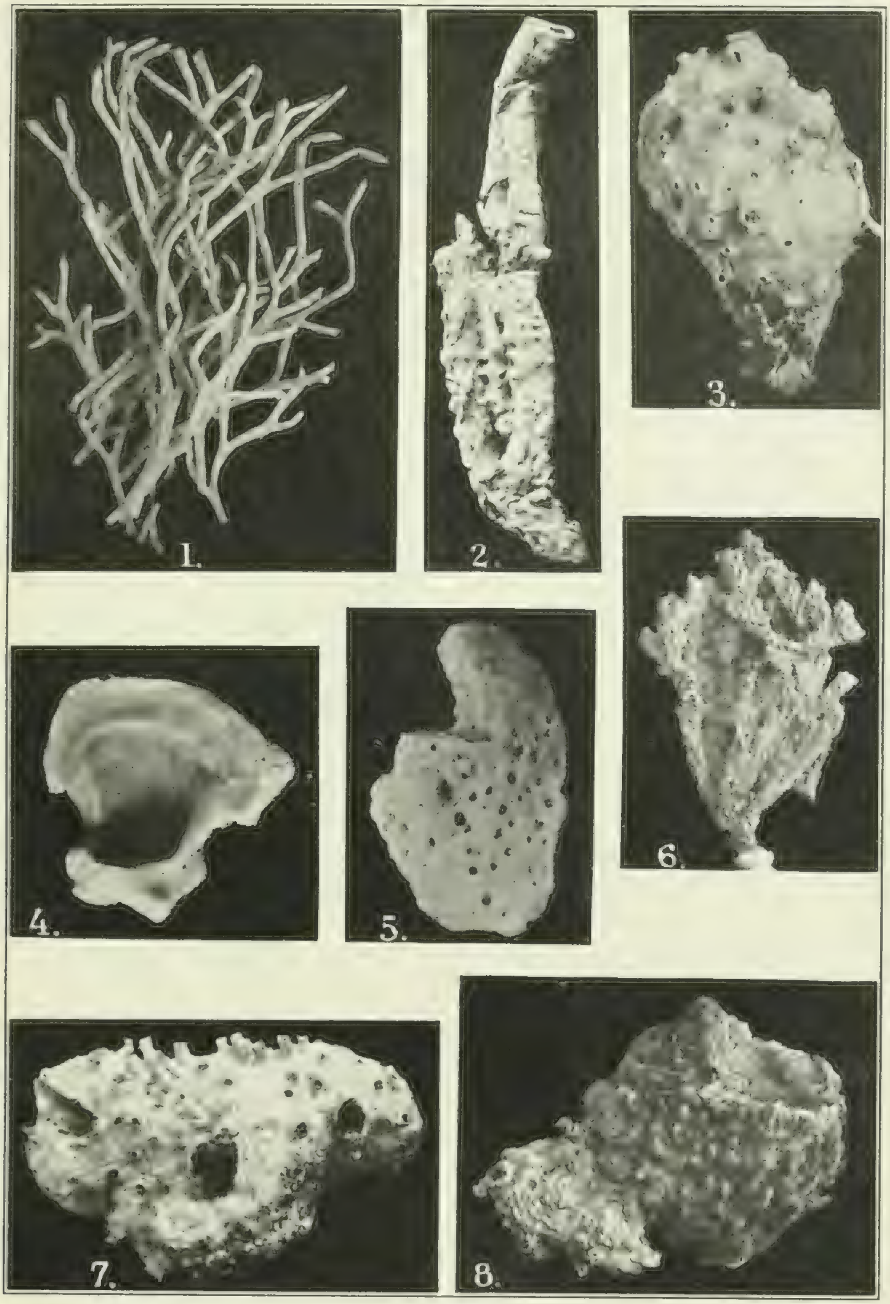
4. *Lissodendoryx tawiensis*. From the inner, concave, side. ×1.

5. *Myxilla crucifera*. From the oscular side. ×1.

6. *Clathria fasciculata*. From the side. ×$\frac{1}{4}$.

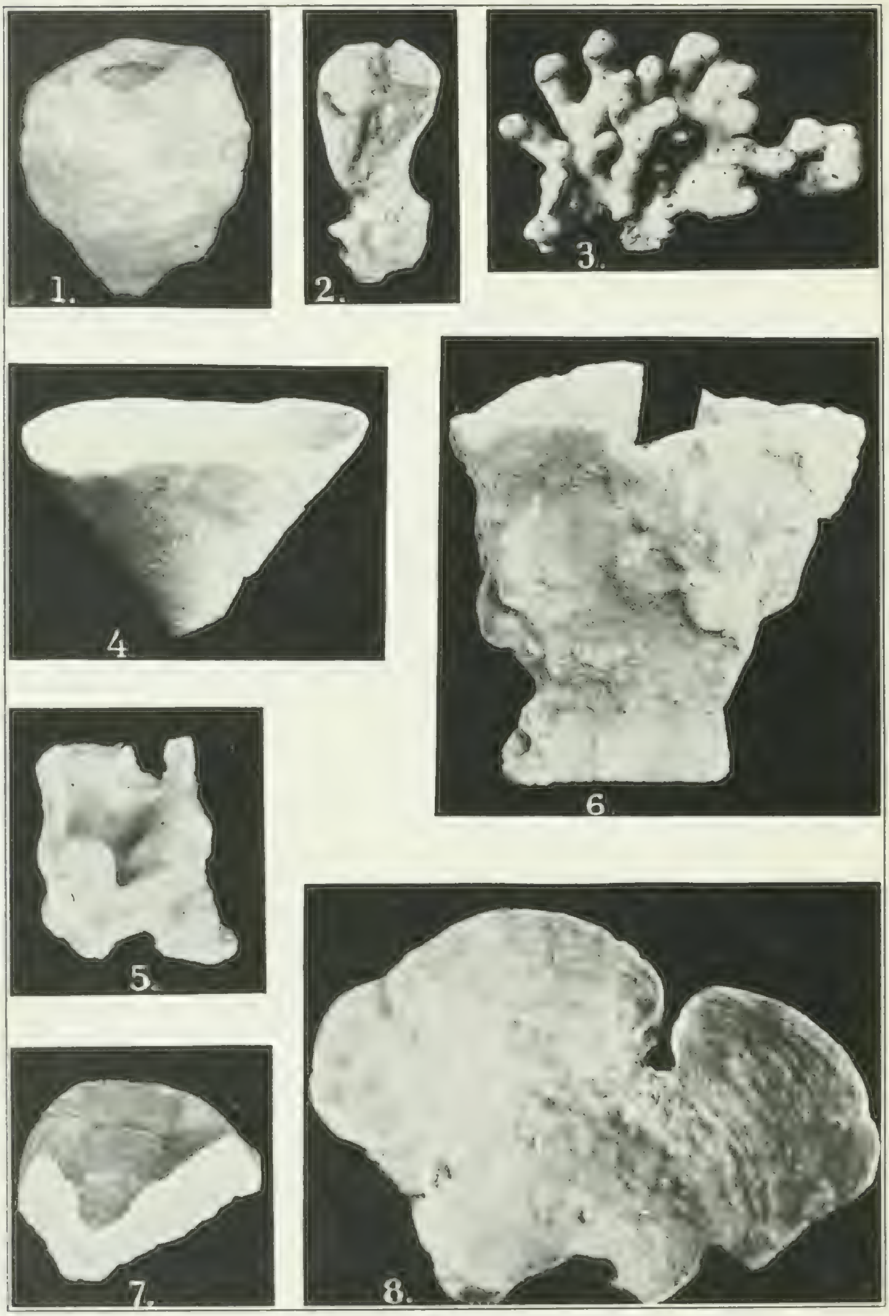
7. *Coelosphaera toxifera*. Obliquely from above. ×$\frac{1}{4}$.

8. *Axinyssa aculeata*. Dried specimen from station 5254, from side. ×$\frac{1}{4}$.



SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 512



SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 513

PLATE 43.

FIG. 1. *Theonella swinhoei*, var. *verrucosa*. From the side. ×⅓.

2. *Theonella invaginata*. Sponge bisected, showing cloaca with apical aperture and two lateral diverticula which also open on the surface. ×1.

3. *Jereopsis fruticosa*. Sponge mass from the side. ×$\frac{3}{4}$.

4. *Leiodermatium pfeifferae* (Carter). Vase-shaped specimen. ×$\frac{4}{5}$.

5. *Discodermia emarginata*, var. *lamellaris*. Showing the concave (oscular) face of the lamella which arises from an amorphous base. ×1.

6. *Costifer vasiformis*. Vase-shaped sponge, from the side. ×$\frac{1}{4}$.

7. *Aciculites ciliata*. The cup-shaped sponge has been bisected. From the cut surface. ×1.

8. *Leiodermatium pfefferae* (Carter). Lamellate specimen. ×$\frac{4}{5}$.

PLATE 44.

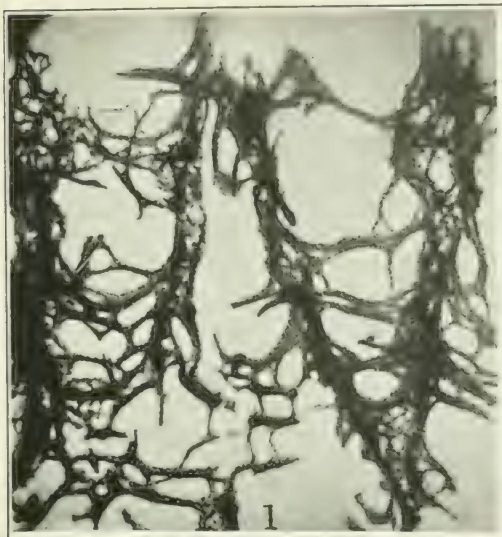
FIG. 1. *Spongelia fragilis* (Montagu), var. *fasciculata.* From a thick section vertical to surface of sponge, showing four main fibers and connectives. The conular terminations of the fibers appear in the preparation, which has been macerated in caustic potash. ×15.

2. *Hircinia mutans.* From above. ×$\frac{1}{3}$.

3. *Psammaplysilla kelleri.* From a transverse section (75 μ thick, Delafield's haematoxylin): Showing branching fibers with coarse concentric stratification and the included, small, opaque masses of pigmented cells. ×37.

4. *Theonella cylindrica.* From the side; the gap indicates where a piece was removed from the specimen. ×$\frac{7}{8}$.

5. *Taprobane herdmani* Dendy. Sponge, a complex of vases, seen from the side. ×$\frac{1}{3}$



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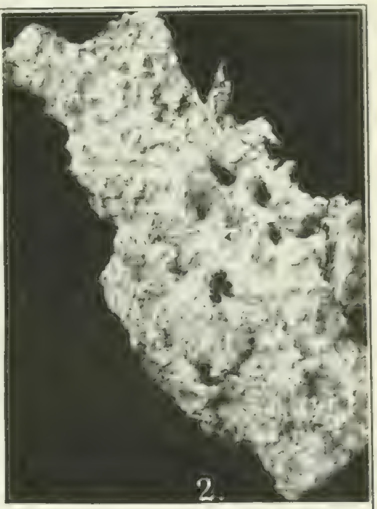

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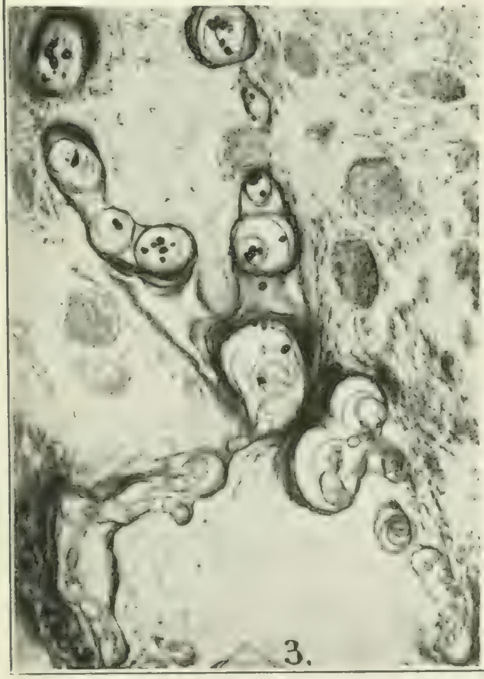

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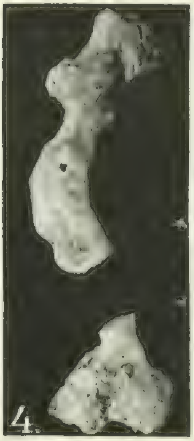

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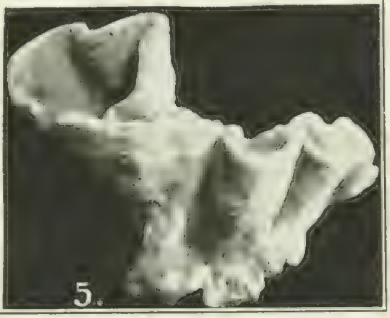
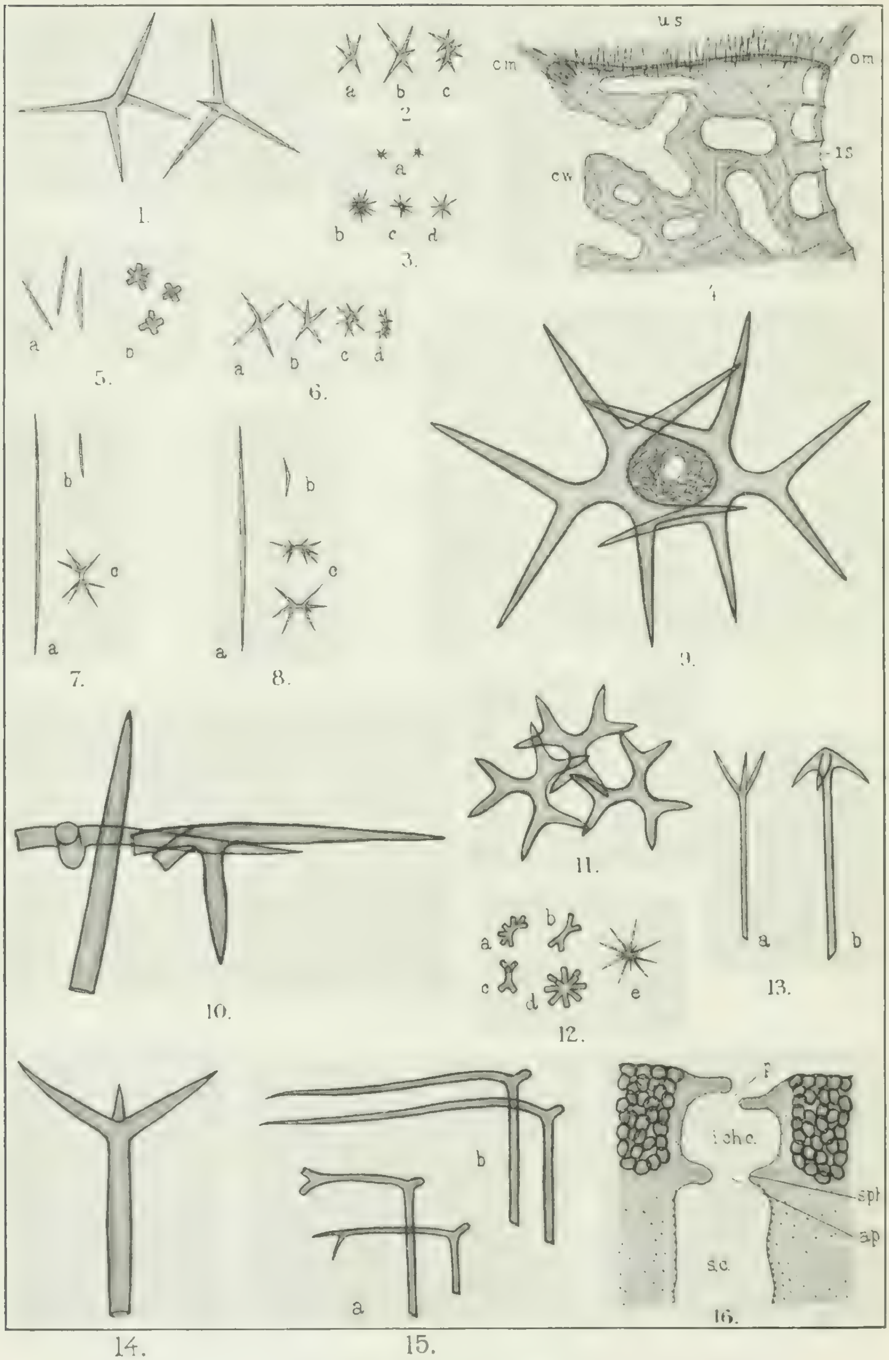


5.

SILICIOUS AND HORNY SPONGES FROM PHILIPPINE WATERS

FOR EXPLANATION OF PLATE SEE PAGE 614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Silicious and Horny Sponges from Philippine Waters

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Plate 45.

- Fig. 1. *Thenea grayi* Sollas. Plesiasters. ×220.
- 2. *Thenea grayi* Sollas. *a*, *b*, metasters; *c*, spiraster. ×220.
- 3. *Stelletta radicifera*. *a*, dermal oxyasters; *b*, ectosomal oxyaster with large centrum; *c*, ectosomal oxyaster with smaller centrum and fewer rays; *d*, choanosomal oxyaster with no centrum. ×600.
- 4. *Sphinctrella bifacialis*. Part of a vertical section including upper surface, *u. s.*, lateral surface, *l. s.*, and cloacal wall, *c. w.*, of sponge The outer, *o. m.*, and cloacal, *c. m.*, margins of upper surface both bear long spicules; canals open on the cloacal surface. Somewhat diagrammatic. ×4.
- 5. *Erylus cornutus*. *a*, microrhabds; *b*, strongylasters. ×400.
- 6. *Sphinctrella bifacialis*. Streptasters. ×220.
- 7. *Characella abbreviata*. *a*, choanosomal microxea; *b*, dermal microxea; *c*, streptaster. *a*, *b*, ×240; *c*, ×600.
- 8. *Poecillastra ciliata*. *a*, choanosomal microxea; *b*, dermal microxea; *c*, streptasters. *a*, *b*, ×240; *c*, ×600.
- 9. *Poecillastra ciliata*. Skeletal arrangement of dermal surface. Cladomes of triaenes bound meshes; in each mesh a canal aperture; dermal microxeas are represented in the enclosed mesh. ×90.
- 10. *Characella abbreviata*. Skeletal arrangement; triaenes at the surface, and large projecting oxeas. From a section vertical to the surface. ×90.
- 11. *Stelletta radicifera*. Cladomes of dichotriaenes at surface of sponge. ×90.
- 12. *Tethyopsis dubia*. *a*, *b*, *c*, *d*, strongylasters of four types; *e*, oxyaster. ×1,000.
- 13. *Stelletta radicifera*. From a radial section; *a*, projecting protriaene; *b*, anatriaene of radial bundle. ×240.
- 14. *Tethyopsis dubia*. Plagiotriaene. ×90.
- 15. *Tethyopsis dubia*. Orthodiaenes. *a*, type in which the long clad is dichotomous; *b*, ordinary type. ×45.
- 16. *Erylus cornutus*. From a vertical section through cortex of outer surface showing pore, *p*, in the sterraster-free area of dermal membrane; incurrent chone-canal, *i. ch. c.*; sphincter, *sph*, limiting the aperture, *ap*, of chone canal into subcortical canal, *s. c.* ×25.

Plate 46

Fig. 1. *Erylus cornutus.* *a*, *b*, orthodiaenes in side view, *c*, cladome seen from below. ×90.

2. *Erylus cornutus.* *a*, sterraster in edge view; *b*, same in face view. Rays shown only over a part of the surface of the sterraster in both figures. ×240.

3. *Geodia philippinensis.* From a vertical section showing a dichotriaene in the ectochrote accompanied by two anatriaenes and a protriaene; dermal membrane indicated by small asters; ectosomal oxeas radial to dermal membrane; outermost sterrasters shown. ×90.

4. *Geodia philippinensis.* *a*, dermal oxyasters; *b*, choanosomal oxyaster. ×600.

5. *Geodia philippinensis.* Cladomes of two dichotriaenes in natural position in the dermal membrane. ×90.

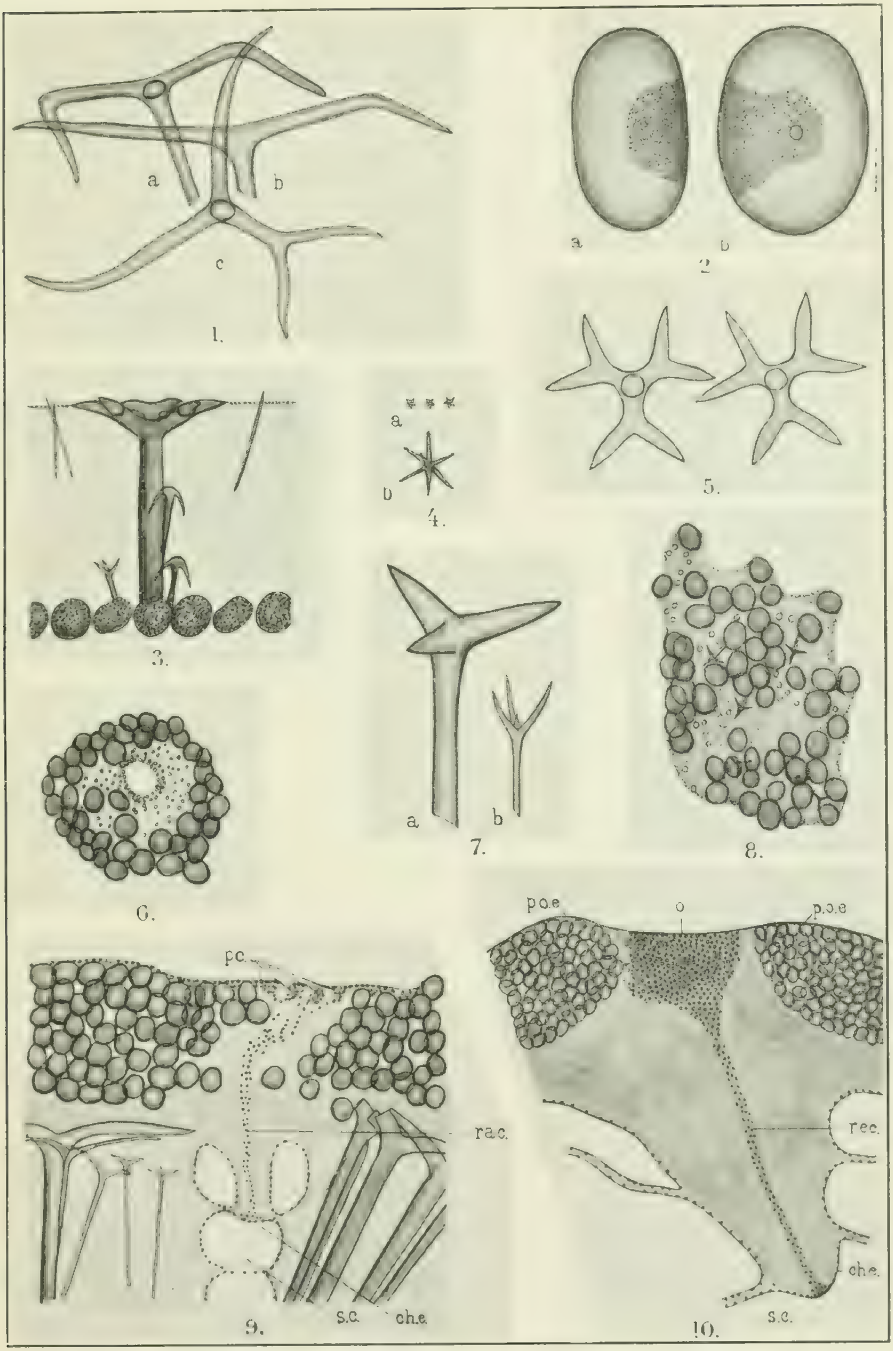
6. *Sidonops microspinosa.* Pore area with open pore. Spherasters crowded round edge of pore. ×140.

7. *Geodia sparsa.* *a*, plagiotriaene from the side. ×160; *b*, projecting protriaene with prolonged rhabdome. ×300.

8. *Geodia sparsa.* Part of dermal surface, showing distribution of plagiotriaenes; also sterraster-free tracts with open pores. ×45.

9. *Sidonops microspinosa.* Vertical section through a pore area and afferent chone canal. *p. c.*, oblique pore canals, probably four, marked by spherasters; *r. a. c.*, radial afferent chone canal marked by a streak of oxyasters; *ch. c.*, inner end of chone; *s. c.*, subcortical crypt. ×140.

10. *Sidonops microspinosa.* Vertical section through an oscular area. *p. o. c.*, periosculur elevation; *r. e. c.*, radial efferent chone canal, marked along most of its extent by a streak of oxyasters, but above by a dense accumulation of spherasters indicating the position of the osculum, *o*, which is actually closed; *ch. c.*, inner end of chone; *s. c.*, subcortical crypt. ×85.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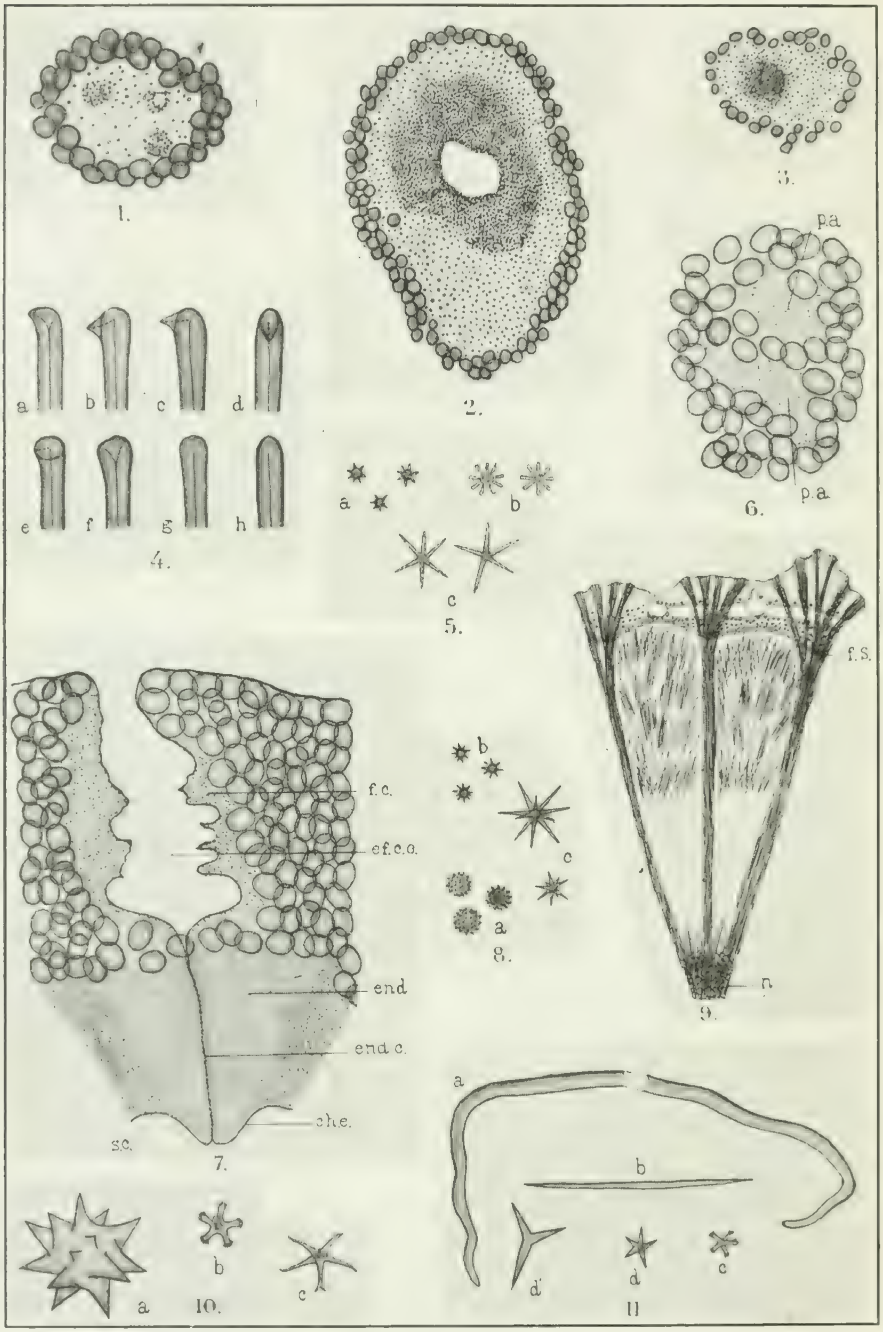
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PLATE 47

FIG. 1. *Sidonops microspinosa.* Pore area. One pore not completely closed. Two dense groups of spherasters indicate closed pores. ×140.

2. *Sidonops microspinosa.* Oscular area with an open osculum. Spherasters densely crowded round osculum. ×85.

3. *Sidonops microspinosa.* Oscular area with closed osculum. Position of latter indicated by an accumulation of spherasters. ×85.

4. *Geodinella spherastrosa.* Reduced triaenes. *a*, *b*, *c*, monaenes with comparatively sharp vestigial clad in side view; *d*, same with clad showing in face view; *e*, *f*, monaenes in which the vestigial clad is reduced to a slight rounded protuberance shown in side view; *g*, *h*, completely degenerate spicules in which there is no sign of a clad, the axial canal sending off no branch. ×175.

5. *Geodinella spherastrosa.* *a*, dermal spherasters; *b*, strongylasters from cortical canals; *c*, oxyasters from choanosome. ×600.

6. *Geodinella spherastrosa.* Surface, showing sterraster-free pore areas, *p. a.* ×45.

7. *Geodinella spherastrosa.* Vertical section through cortex. *ef. c. c.*, efferent chone canal opening above by an osculum; *end. c.*, closed canal of endochone marked by a streak of strongylasters; *ch. e.*, inner end of chone; *end.*, dense fibrous tissue of contracted endochone; *f. c.*, fibrous collenchyma round chone canal; *s. c.*, wall of subcortical canal. ×45.

8. *Sidonops microspinosa.* *a*, spherasters; *b*, oxyasters from cortical canal; *c*, larger oxyasters from choanosome. ×600.

9. *Donatia ingalli*, var. *seychellensis* (E. P. Wright). From a radial section. *f. s.*, fibrous stratum of ectosome; *n*, skeletal "nucleus." ×7½.

10. *Donatia ingalli*, var. *seychellensis* (E. P. Wright). *a*, spheraster ×600; *b*, chiaster (acanthtylaster) ×1,000; *c*, choanosomal oxyaster ×600.

11. *Jaspis serpentina.* *a*, skeletal twisted rhabd, only terminal parts shown, ×100; *b*, small oxea ×300; *c*, chiaster (acanthtylaster) ×1,000; *d*, *d′*, oxyasters ×500.

PLATE 48

FIG. 1. *Trichostemma straticulatum.* Median section. *a. r. b.*, ascending radial skeletal bundle; *ch*, choanosome; *fr. s.*, fringe spicules; *l. c. m.*, middle stratum of lower cortex; *o. c.*, oscular canal; *u. c. m.*, middle stratum of upper cortex. ×7½.

2. *Strongylophora corticata.* Skeletal spicules. *a*, strongyle; *b*, oxea ×225.

3. *Spongosorites suluensis.* Vertical section through the lamellate sponge. *n. e.*, natural edge; *o. s.*, oscular surface; *p. s.*, pore surface. ×7½.

4. *Tetilla (Cinachyrella) paterifera.* Anatriaene forms. *a*, common form seen in optical section; *b*, aberrant form with very short rounded clads; *c*, monaene form; *d*, tylostyle form; *e*, aberrant form with very short rounded clads and rhabdome produced beyond the cladome (anamesotriaene type). ×450.

5. *Tetilla (Cinachyrella) crustata.* From a section vertical to the surface. *a–b*, thickness of ectosomal layer of tangential oxeas. ×160.

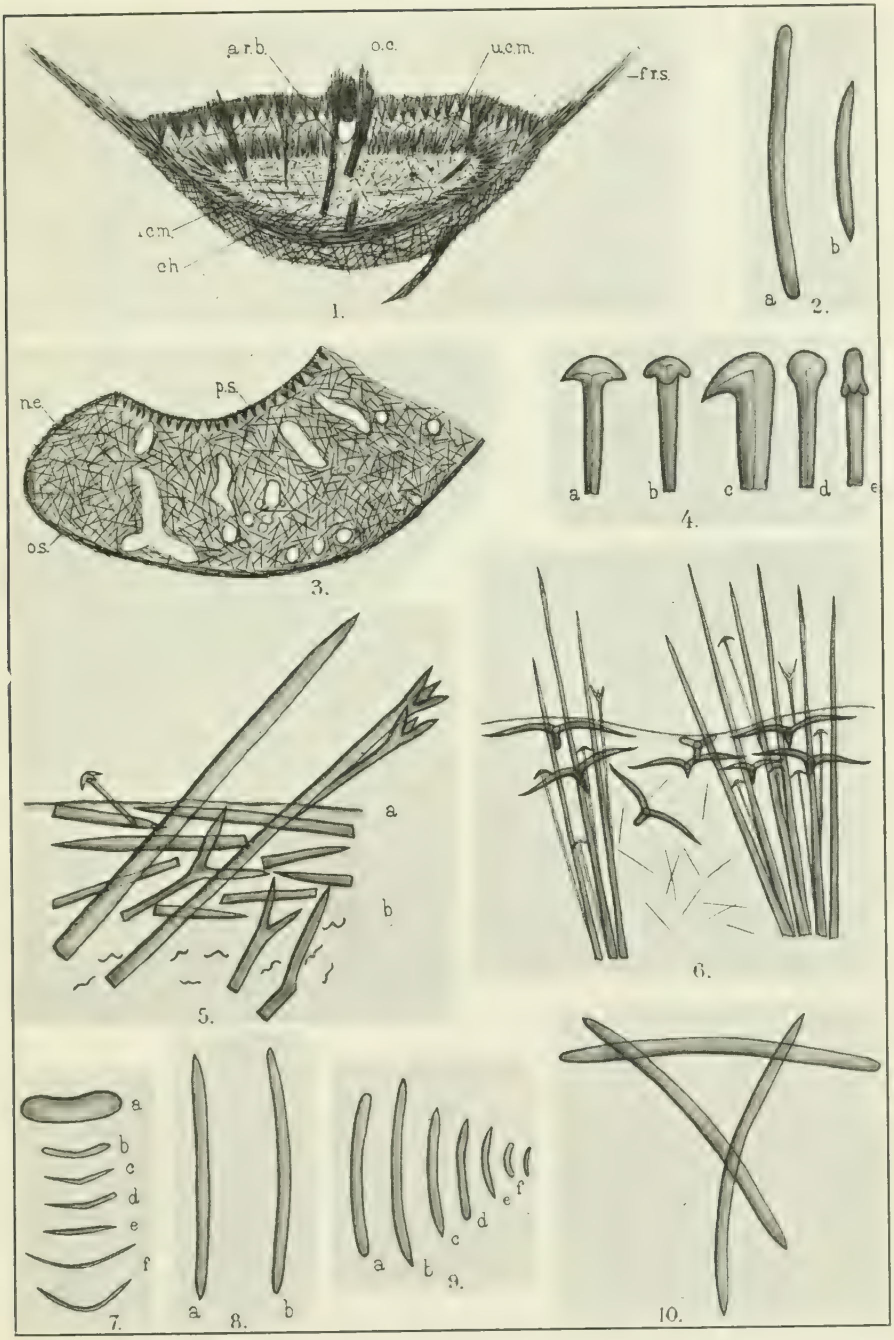
6. *Paratetilla arcifera.* From a radial section. ×45.

7. *Strongylophora corticata.* Spicules of microsclere size. *a*, small stout strongyle; *b*, small slender strongyle; *c*, characteristic angulated microxea; *d*, microstrongyle, a rare form; *e*, nearly straight microxea; *f*, very slender oxeas curved much like toxas but without the recurved ends of the latter. ×650.

8. *Petrosia testudinaria*, var. *fistulophora.* *a*, skeletal spicule, an oxea, of specimen from station 5254; *b*, skeletal spicule, an intermediate with tapering ends rounded at the extremity, of specimen from sta. 6253. ×150.

9. *Petrosia lignosa.* Spicules. *a*, strongyle with broadly rounded ends from specimen taken at station 5250. Other spicules from specimen taken at station 5147. *b*, intermediate (oxea with rounded ends); *c*, *e*, oxeas; *d*, style (a rare form); *f*, small strongyles. ×150.

10. *Phloeodictyon cagayanense.* Spicules: oxeas, one more abruptly pointed than the other, and strongyle. ×400.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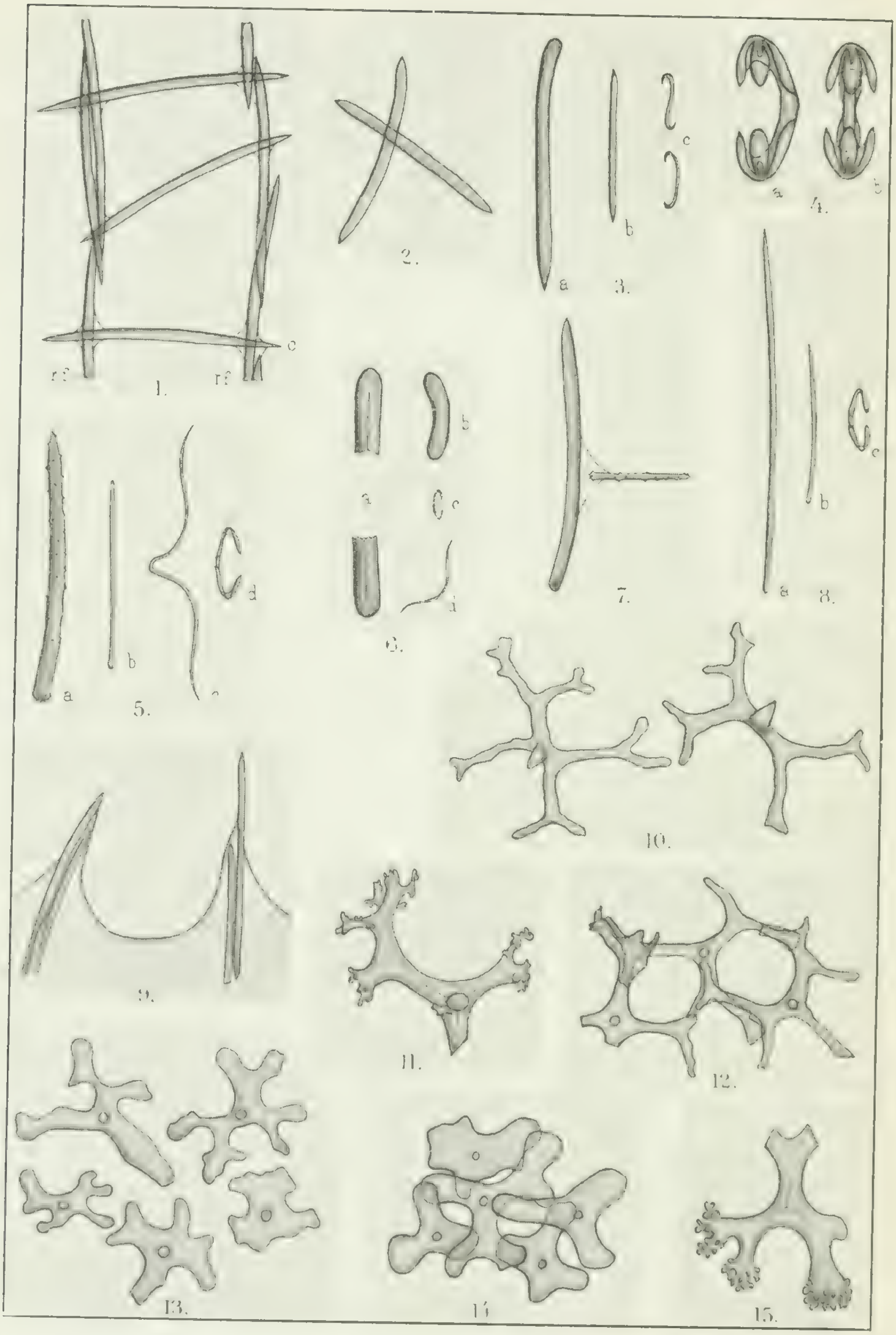
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Silicious and Horny Sponges from Philippine Waters

For explanation of plate see page 519

Plate 49

Fig. 1. *Gellius varius*, var. *fibrosa*. From a vertical section, showing part of skeletal reticulum including two radial fibers, *r. f.*, with connectives, *c.* ×350.

2. *Petrosia crustata*. Spicules. ×375.

3. *Myxilla crucifera*. *a*, skeletal style; *b*, ectosomal tornote; *c*, sigmas in two positions. ×240.

4. *Myxilla crucifera*. Ancoras (tridentate isancoras). *a*, side view; *b*, ventral view. ×1100.

5. *Lissodendoryx tawiensis*. *a*, skeletal style; *b*, ectosomal tylostrongyle; *c*, toxa; *d*, isochela. *a*, *b*, *c*, ×240; *d* ×1,100.

6. *Coelosphaera toxifera*. *a*, the two ends of a typical strongyle; *b*, one of the very small strongyles; *c*, isochela; *d*, toxa. ×400.

7. *Clathria fasciculata*. Style of the skeletal fiber and echinating acanthostyle, basal end of the latter buried in the spongin of the fiber. ×400.

8. *Clathria fasciculata*. *a*, *b*, large and small dermal styles. ×400; *c*, isochela. ×1,100.

9. *Axinyssa aculeata*. From a vertical section, showing two dermal conuli with included spicules. ×60.

10. *Theonella swinhoei*, var. *verrucosa*. Phyllotriaenes seen from below. ×90.

11. *Theonella invaginata*. Nearly the whole of an isolated, not fully developed, desma. ×210.

12. *Theonella invaginata*. Dermal phyllotriaenes. ×100.

13. *Theonella invaginata*. Gastral phyllotriaenes of a less modified type than those of fig. 14. ×100.

14. *Theonella invaginata*. Gastral phyllotriaenes. ×100.

15. *Theonella invaginata*. Part of a fully developed desma. ×210.

Plate 50

Fig. 1. *Theonella cylindrica.* Phyllotriaenes. *a*, cladome from above; *b*, cladome from below. ×150.

2. *Theonella cylindrica.* Part of the desmal framework. ×230.

3. *Theonella cylindrica.* Young desma, from periphery of sponge; clads breaking up terminally into short branches which bear the irregular tubercles of zygosis. ×230.

4. *Jereopsis fruticosa.* Small free amphitriaenes from the ectosome. In one of the spicules drawn, the axial canal could not be distinctly traced at one end of the spicule. ×150.

5. *Jereopsis fruticosa.* Young desma with simple clads from ectosome, after treatment with hydrofluoric acid which has somewhat corroded the spicule. ×150.

6. *Jereopsis fruticosa.* Streptasters. *a*, amphiaster from interior; *b*, amphiaster from interior approaching the spiraster type; *c*, spiraster from dermal surface. ×620.

7. *Jereopsis fruticosa.* An uncorroded and nearly perfect desma detached from the skeleton in sectioning; a bit of an adjoining desma in zygosis is also shown. ×150.

8. *Costifer vasiformis.* Rare types of desma; main axis bearing a clad or a few clads; articular facets on epirhabd only. ×45.

9. *Jereopsis fruticosa.* Skeletal desmas isolated with hydrofluoric acid and therefore corroded. The two sets of clads at opposite ends of the shaft may be about equally developed, as in *a*. Or the clads at one end are much more extensively developed than at the other end, as in *b* and *c*. ×150.

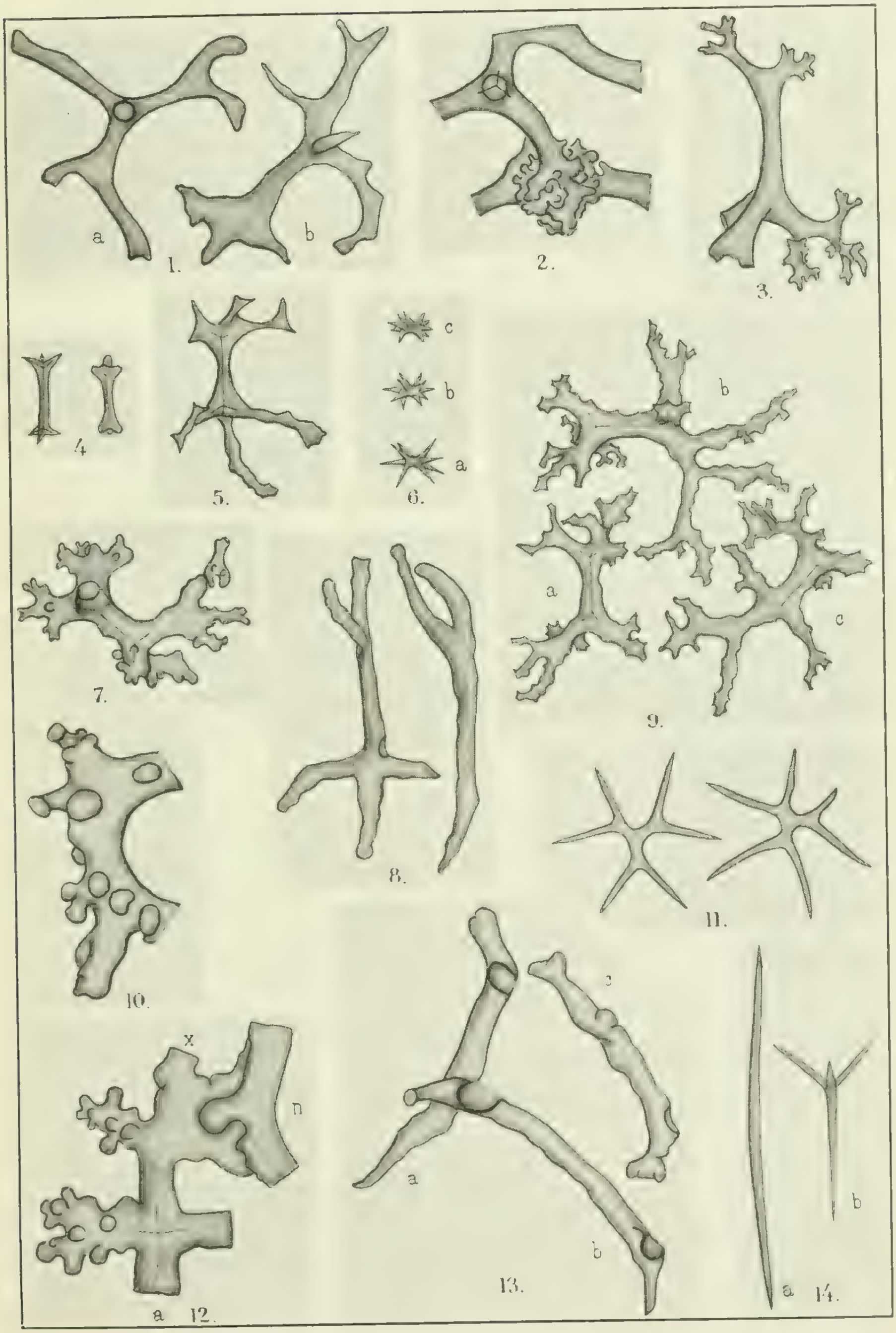
10. *Coscinospongia thomasi* (Sollas). Part of a developed desma. ×220.

11. *Jereopsis fruticosa.* Dichotriaenes. ×150.

12. *Jereopsis fruticosa.* One end of a fully developed uncorroded desma forming part of the skeletal framework. *a* is the shaft. Of the three primary branches into which it breaks at this end, only one is covered with the tubercles of zygosis. The middle primary branch divides into three secondaries. The middle secondary divides into two tertiaries, one of which, *x*, ascends to pass into a skeletal node at another level. *n*, a skeletal node as seen at a single focus; the entire node is much more complex, several desmas interlocking to form it. ×210.

13. *Costifer vasiformis.* Common types of desma, rod-like and without clads. *a*, and *b*, still interlocking, each with two facets; *c*, with ends that are somewhat gnarled. ×45.

14. *Costifer vasiformis.* *a*, oxea; *b*, plagiotriaene. ×45.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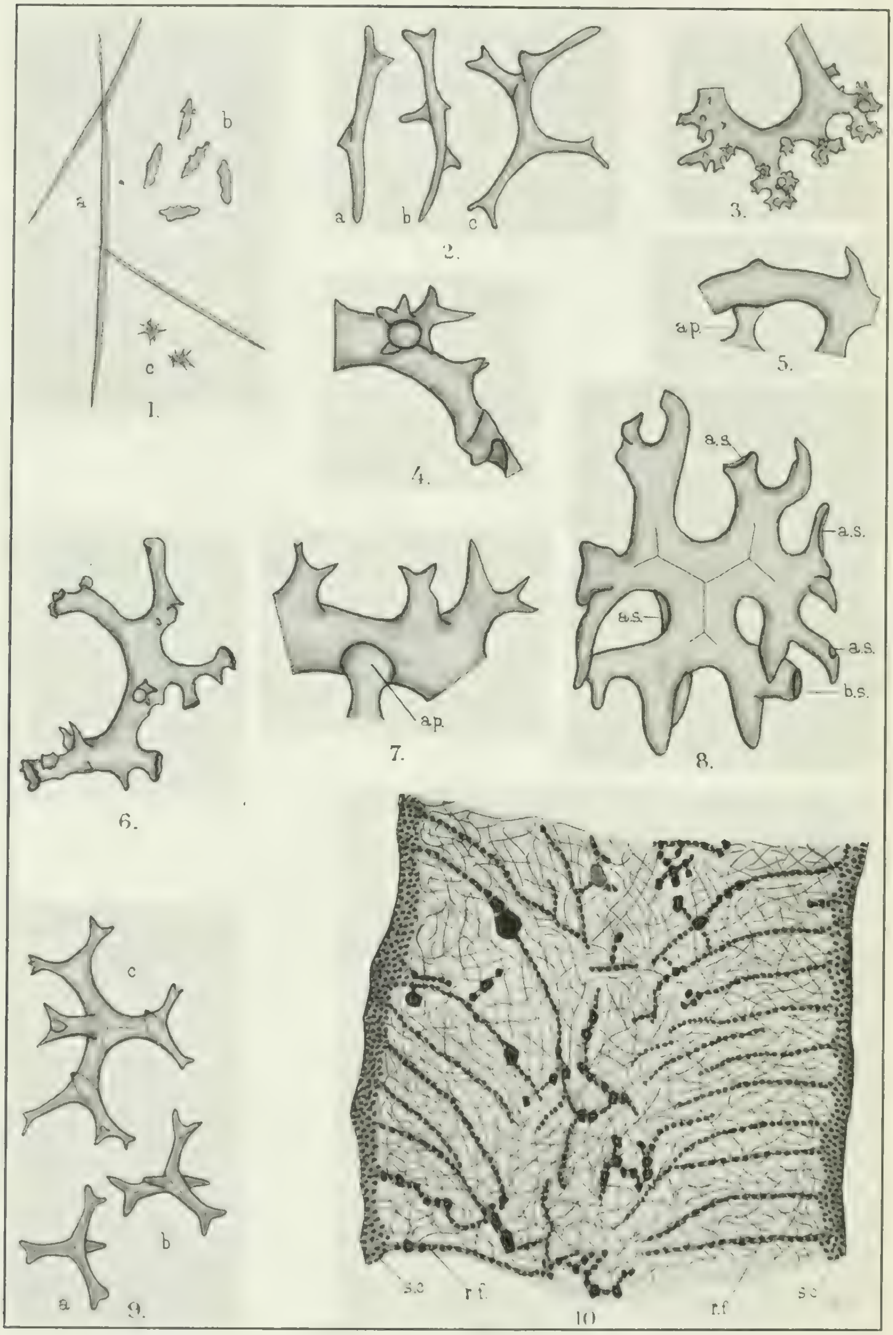
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PLATE 51

FIG. 1. *Costifer vasiformis.* *a*, microxeas; *b*, microstrongyles; *c*, streptasters. ×150.

2. *Aciculites ciliata.* Undeveloped desmas from just below dermal membrane of margin of the cup-shaped sponge. *a*, very young; *b*, somewhat older; *c*, still older form. ×220.

3. *Aciculites ciliata.* Part of adult desma, showing characteristic tubercles. ×220.

4. *Leiodermatium pfeifferae* (Carter). Part of a desma showing a rosette of three bidentate spinous tubercles, a single sharp bidentate tubercle, and a concave facet for zygosis. ×400.

5. *Leiodermatium pfeifferae* (Carter). Articulation of a simple kind. A clad, *a. p.*, of one desma is simply apposed to another desma. ×220.

6. *Leiodermatium pfeifferae* (Carter). An entire desma. ×220.

7. *Leiodermatium pfeifferae* (Carter). Part of desma bearing spinose tubercles embraced by an expanded articular process, *a. p.*, of another desma. ×400.

8. *Brachiaster simplex.* Cladome of adult desma (a dichotriaene); most of the secondary branches with tertiaries, one with quarternary branches. *a. s.*, articular surface; *b. s.*, broken surface. ×85.

9. *Brachiaster simplex.* Young desmas. *a*, simple dichotriaene form. *b*, simple dicho-mesotriaene form. *c*, mesotriaene in which two of the primary clads and the distal axial ray break up, each into three branches; rhabdome unbranched; nearly all secondary branches beginning to acquire tertiary branches. ×85.

10. *Phyllospongia aliena.* Part of a section through the lamellate sponge, vertical to the surface and radial to the free margin of the sponge; figure includes both surfaces. *r. f.*, radial fiber; *s. c.*, sand cortex. ×20.

PLATE 52

Fig. 1. *Phyllospongia aliena.* From a vertical section, showing a radial fiber, *r. f.*, containing sand grains and foreign spicules, with connectives crossing it. One connective, *a*, starts from the radial fiber; others are all cemented to it by spongin; *sy*, a synapticulum. ×150.

2. *Hircinia mutans.* Two main fibers, *m. f.*, and connectives, latter ranging from simple fibers to fenestrated plates. Connectives not indicated along free edge of right fiber. ×45.

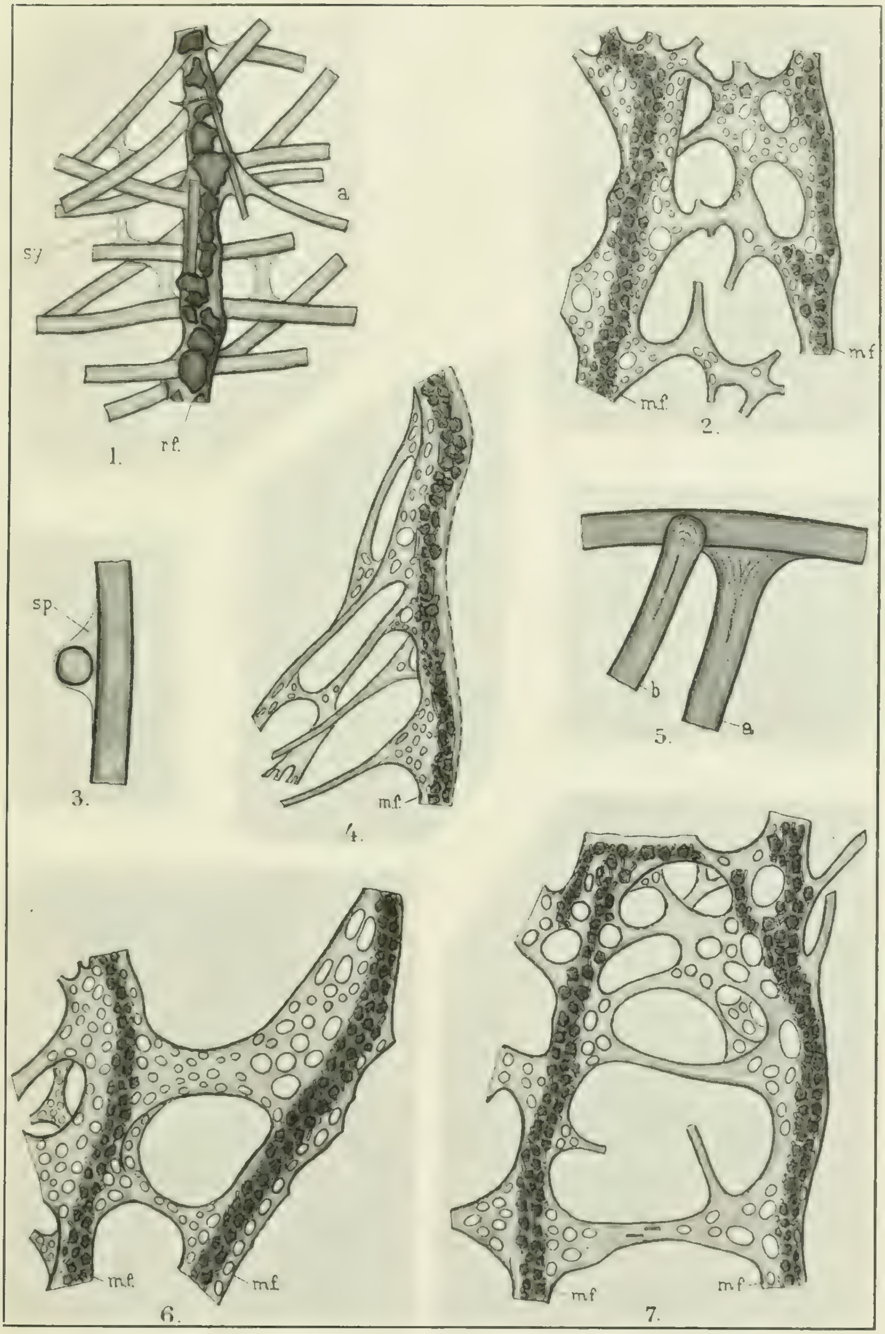
3. *Phyllospongia aliena.* Two connectives crossing one another cemented together by spongin, *sp.* ×300.

4. *Hircinia mutans.* A main fiber, *m. f.*, with connectives meeting it on one side. Origin of connectives on other side of fiber not shown. ×45.

5. *Phyllospongia aliena.* Connectives. One connective, *a*, ends in a spongin expansion on the side of another; in the expanded portion strata, parallel to the surface, are faintly distinguishable. The free end of another fiber, *b*, appears; its outer border is here no more cuticular in appearance than is the case with spongin which cements fibers together; terminal region faintly stratified. An axial medullary streak is distinguishable in both fibers, *a* and *b*, near the end. ×300.

6. *Hircinia mutans.* Two main fibers, *m. f.*, with connectives. One of the connectives is a fenestrated membrane of considerable width; the other is narrower. The roots (fenestrated expansions) of connectives have spread out extensively along the sides of the primitive (simple, solid) main fibers. Origin of connectives from far side of right fiber not shown. ×45.

7. *Hircinia mutans.* Two main fibers, *m. f.*, with connectives. Latter in part simple, meeting the main fibers in the usual way, in part (above) combined to form a fenestrated membrane. Connectives not indicated along free edge of right fiber. ×45.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THE SHIPWORMS OF THE PHILIPPINE ISLANDS

By Paul Bartsch

Curator, Division of Mollusks, United States National Museum

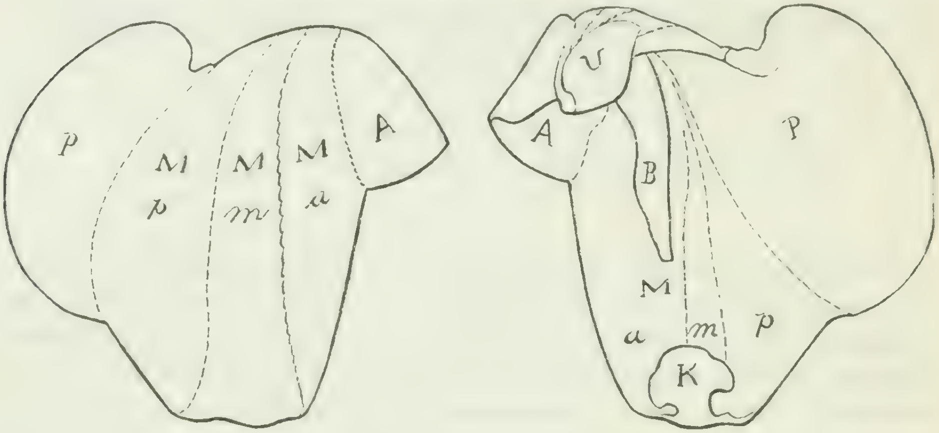
Our card catalogue of the Philippine mollusks contains no reference to shipworms in Philippine waters. I fear that the work during the Philippine Expedition of the United States Bureau of Fisheries Steamer *Albatross* also failed to stress this much neglected field of research. This is not to be wondered at since shipworms are among the most inconspicuous mollusks that the sea harbors. Pilings and drift wood infested by them rarely ever proclaim their presence until they begin to disintegrate, for the tiny punctures on their outer surface are too small to reveal the enemy gnawing at their heart. It is only when a great efflorescence of these forms produces an outbreak that threatens all unprotected shipping in a region, that they come to their own and are allotted a conspicuous status for interfering with the economics of man. The importance which the shipworm problem has assumed since the outbreak in San Francisco Bay, California, during 1919–20 would, were I again to visit the Philippines, cause me to keep a sharper lookout for shallow water forms than I did during the *Albatross* expedition, and I am sure that such an effort would result in the material expansion of the list here offered.

Most of the shipworms here described were taken from pieces of wood brought up by our dredge sometimes from considerable depth, at various stations. It is a remarkable fact that our dredging at the mouth of rivers, even when these emptied into semienclosed bays, yielded only fragments of wood, and these fragments were always honey-combed and riddled by boring mollusks which destroy the water-logged wood in such places and prevents the formation of wood deposits in salt water lagoons.

I wish here to express my appreciation to John A. Mirguet, preparator in the Division of Mollusks of the United States National Museum, for it was his skillful excavating that has kept the pallets associated with the shell to which they belong. Only those who have attempted work of this kind when dealing with dry riddled wood, will realize the great care and patience necessary for this

work. I wish also to express my appreciation to Mrs. E. B. Decker, artist in the Division of Mollusks, for the careful drawing here reproduced.

FIG. 1.—EXTERIOR AND INTERIOR OF SHELL TO SHOW THE TERMINOLOGY USED IN THE DESCRIPTIONS



A. Anterior part.
M. Median part.
P. Posterior part.

a. Anterior portion of median part.
m. Middle portion of median part.
p. Posterior portion of median part.

U. Umbones.
B. Blade.
K. Knob.

Genus **BANKIA** Gray

1840. *Bankia* GRAY, Synop. British Mus., p. 76.
1922. *Bankia* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 7.

The genus is characterized by having the pallets consisting of a series of cone-in-cone structures, which give to them the appearance of an ear of wheat.

Type.—*Teredo bipalmulata* Lamarck.

Subgenus BANKIA Gray

1840. *Bankia* GRAY, Synop. British Mus., p. 76.
1922. *Bankia* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 7.

In this subgenus the distal end of the cones terminates in a thin membrane, which is fimbriated at the free margin. The lateral fimbriations form long awnlike projections.

Type.—*Teredo bipalmulata* Lamarck.

BANKIA (BANKIA) PHILIPPINENSIS, new species

PHILIPPINE SHIPWORM

Plate 53, figs. 1, 3; plate 56, fig. 8; plate 58, figs. 7, 8, 9

Shell small, white. Umbone badly eroded. The anterior portion covered by a heavy callused smooth area which is about one-third as wide as the remaining anterior part. The dental ridges curve suddenly downward, immediately posterior to the callus, and then extend in an even curve backward. Forty-four of these ridges are present in the type, but this is by no means the entire number, for the early ones are completely eroded at the umbone. The ridges slope a little more abruptly dorsally than ventrally, and are exceedingly finely denticulated at the free margin. The anterior median area is very broad; in fact in the type, which is the only specimen available, it constitutes the entire median area. This, however, may be due to erosion. The dental ridges of this part are almost twice as wide as those on the anterior area. There are 40 in a line parallel to the ventral margin of the anterior part. These ridges are strongly denticulated. Posterior to the denticulated median portion the shell slopes abruptly down into a very narrow shoulder, beyond which only a very slender auricle projects. The middle and posterior median part are apparently absent. Should this prove to be the usual state of affairs, and not merely due to erosion, it will be necessary to transfer this animal to a new genus. Interior bluish white. Suture of the anterior and anterior median portion marked by a raised cord. The posterior border of the median part is thickened and bears the knob at its ventral margin. A very slender auricle is present, which partly glazes over the middle part, forming the merest indication of a shelf almost resembling *Psiloteredo* in its reduction. A narrow irregular slender blade extends two-thirds of the way from the umbone to the ventral margin of the shell. The pallets are slender with a very slender stalk. The membrane on the outside of the evenly rounded segments is finely fimbriated. The inner border appears to be free of fimbriations and is also evenly curved.

The type (Cat. No. 310970, U.S.N.M.) was obtained by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5243, in 218 fathoms in a piece of wood taken from gray mud bottom, bottom temperature 63.6° in Pujada Bay, eastern Mindanao. It measures: Altitude, 1.3 mm.; length, 1.3 mm.; diameter, 1.3 mm. The pallet measures: Length, 4.6 mm., of which 1.2 mm. go to the stalk; diameter, 0.7 mm.

Another specimen of this species, Cat. No. 310971, U.S.N.M., was collected by the same expedition at station 5252 in 28 fathoms from a piece of wood taken on coral bottom, off Linao Point, Gulf of Davao.

Subgenus NEOBANKIA Bartsch

1921. *Neobankia* BARTSCH, Proc. Biol. Soc., Washington, vol. 34, p. 26.
1922. *Neobankia* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 9.

In Neobankia the pallets consist of cone-in-cone elements, covered by a thin membrane, which is denticulate at the free margin.

Type.—*Bankia* (*Neobankia*) *zeteki* Bartsch.

BANKIA (NEOBANKIA) JOHNSONI, new species

JOHNSON'S SHIPWORM

Plate 53, figs. 5, 13; plate 56, fig. 7; plate 58, figs. 10, 11, 12

Shell of moderate size, subglobular. The anterior area and the anterior median area flesh-colored. The middle median area tinted with the same shade, the rest white. The extreme anterior area is marked by the usual sinus, which is covered by a white callus, which is reflected slightly over the anterior portion. From this callus the dental ridges radiate backward, curving abruptly downward at the extreme anterior portion and then gently backward. These ridges are about half as wide as the spaces that separate them on the early portion of the shell, but become closer spaced as the shell increases in age. The later ridges are separated by mere impressed grooves. The ridges slope more abruptly dorsally than ventrally and are finely denticulated at their free margin. There are 56 present in the type. The line marking the junction of the anterior area and the anterior median portion is wavy. The anterior median portion is rather broad, marked by rather broad denticulated ridges, which meet the dental ridges of the anterior area in a little more than a right angle. There are 28 of these in a line parallel to the ventral border of the anterior part. The middle median portion is slightly concave and crossed by rather strong, irregularly spaced lines of growth. The posterior median portion is almost as wide as the anterior and middle portion combined, and is marked by fine lines of growth only. The junction of the posterior part and the posterior median portion is marked by a strong constriction. The posterior part or auricle appears without sculpture. The interior of the shell is bluish white. The junction of the anterior and median parts is marked by a tumid ridge. The middle median portion is a rough depressed groove, at the tip of which the usual knob is present. The posterior part overlaps the posterior median portion as a strong spoonlike shelf, half of which projects outward and half inward, leaving a decided cavity. The blade is broad, irregularly roughened at the anterior margin and extends for two-thirds of the length of the shell, springing from under the umbone. The pallets are unfortunately fractured in all the specimens at our command. They are of the cone-in-cone type, with the free margin strongly denticulated all around.

The type (Cat. No. 310966, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5269 in 100 fathoms in a piece of wood taken on mud bottom in Batangas Bay, Luzon. The shell measures: Altitude, 4.5 mm.; length, [illegible] mm.; diameter, 4.4 mm. The pallet is too broken to yield measurement.

An additional lot of specimens taken from the same chunk of wood is entered as Cat. No. 246128, U.S.N.M. Still another lot was obtained on the same expedition from a piece of wood at station 5191, in 258 fathoms on green mud bottom, temperature 62.8°, in Tanon Strait, off Refugio Island. This is entered as Cat. No. 310967, U.S.N.M.

I take pleasure in naming this species for Rear Admiral Marbury Johnson, who was in command of the *Albatross* at the time of the expedition.

BANKIA (NEOBANKIA) BARTHELOWI, new species

BARTHELOW'S SHIPWORM

Plate 58, figs. 1, 2, 3

Of the present species, only three pallets are known, the two larger of which belong to the same individual, which I shall designate as type. These are of the cone-in-cone type, with the outer margin forming a shallow cup, while the inner face is much produced and about three times the height of the outer. The outer margin of the segments is beautifully denticulated, while the inner is smooth. These pallets are so characteristic that I do not hesitate to describe the species therefrom.

They measure: Length. 7.7 mm., of which 2 mm. go to the stalk; diameter, 1.2 mm.

They were obtained from the same piece of wood from which the type of *Bankia* (*Neobankia*) *johnsoni* was secured at station 5266, in 100 fathoms on mud bottom in Batangas Bay, Luzon. They are Cat. No. 310968, U.S.N.M.

A couple of loose pallets obtained from a piece of wood collected by the *Albatross* at station 5252, in 28 fathoms on coral bottom, off Linao Point, Gulf of Davao, appear to belong to this species.

The species is named for the late Benjamin Barthelow, executive officer of the *Albatross* during her cruise on the Philippine Expedition.

Subgenus BANKIELLA Bartsch

1921. *Bankiella* BARTSCH, Proc. Biol. Soc. Washington, vol. 34, p. 26.
1922. *Bankiella* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 10.

Pallets consisting of a series of cone-in-cone elements covered by a thin membrane which is neither fimbriated nor denticulated at the free margin, but entire.

Type.—Bankia (*Bankiella*) *mexicana* Bartsch.

BANKIA (BANKIELLA) DAVAOENSIS, new species

DAVAO SHIPWORM

Plate 53, figs. 2, 4; plate 56, fig. 3; plate 58, figs. 4, 5, 6

Shell small, subglobular, white. Anterior area rather broad without a strong callus at its extreme anterior sinus, marked by very strong and strongly denticulated dental ridges which slope more abruptly dorsally than ventrally. Of these ridges 35 are present in the type.

They increase in size regularly from the anterior margin backward. At the posterior termination they are about as broad as the spaces that separate them. The anterior median portion is rather broad and is marked by dental ridges which are as wide as those on the anterior area, but a little more closely spaced and provided with much stronger denticles. Of these ridges 14 can be counted in a line parallel to the ventral border of the anterior portion. The median portion of the middle part is narrow and slightly concave, crossed by the curved continuations of the dental ridges of the anterior median portion, which here lose their denticles. The posterior median portion is narrow and marked by rather coarse lines of growth, the coarser of which coincide with the coarser crossing the median portion. The posterior and middle median portions are not quite as wide as the anterior median portion. No auricle is visible externally. It is possible that this may be eroded in the specimens at hand. Interior bluish white. The anterior and median portions are joined by a cord. The middle median portion appears as a roughened groove, which bears the usual strong knob at its ventral termination. The posterior part laps over the middle part as a heavy callus, which is free at the inner border. This portion is marked by slender parallel threads which gives it a somewhat fluted appearance. A slender, somewhat irregular curved blade extends from under the unbones over two-thirds of the shell. The usual knob is present at the ventral margin of the median part. The cone-in-cone shaped segments of the pallets are of rather a peculiar shape. They appear as a series of scoops in which the outer margin is only about one-fifth as high as the inner margin. The free border of the inner margin forms a convex curve while the free margin of the outer border joins the inner portion in an even concave curve.

The type (Cat. No. 310973, U.S.N.M.) was taken from a piece of wood collected during the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5252, in 28 fathoms on coral bottom off Linao Point, in the Gulf of Davao, Mindanao. It measures: Altitude, 1.3 mm.; length, 1.2 mm.; diameter, 1.3 mm. Length of pallets, 3 mm., of which 0.7 mm. go to the stalk; diameter of pallets, 1 mm.

Several additional pallets from the same piece of wood are entered as Cat. No. 310974, U.S.N.M.

Genus TEREDO Linnaeus

1758. *Teredo* LINNAEUS, Syst. Nat., ed. 10, p. 651.
1922. *Teredo* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 17.

In this genus the pallets are either paddle or spoon shaped. They may be distally cupped or not, or they may even bear a calcareous knob at the terminal portion.

Type.—Teredo navalis Linnaeus.

Subgenus COELOTEREDO Bartsch

1923. *Coeloteredo* BARTSCH, Proc. Biol. Soc. of Washington, vol. 36, p. 99.

In this subgenus the blade of the pallet forms a half hollow cone; that is, the outer portion is convex while the inner portion of the blade is almost flat. The entire structure is very thin. The stalk is short with the basal half expanded into an oval knob, which is fully three times as wide as the narrower neck of the stalk.

Type.—Teredo (*Coeloteredo*) *mindanensis* Bartsch.

TEREDO (COELOTEREDO) MINDANENSIS Bartsch

MINDANAO SHIPWORM

Plate 53, figs. 10, 12; plate 56, fig. 6; plate 60, figs. 4, 8, 12

1923. *Teredo* (*Coeloteredo*) *mindanensis* BARTSCH, Proc. Biol. Soc. Washington, vol. 36, pp. 99–100.

Shell small, subglobular, white, the extreme anterior portion of the anterior part with a moderately deep sinus that is covered with a smooth callus, which is slightly reflected over the exterior portion. The remaining anterior part is crossed by moderately strong dental ridges which first bend downward and then backward in an even, gentle curve, separated at the posterior extremity by spaces about twice as wide as the dental ridges. These dental ridges slope a little more abruptly dorsally than ventrally, and are very finely denticulated at their free border. There are 42 of these in the type, in which the umbone is partly eroded. A perfect specimen would therefore show a large number. The anterior part of the median area is marked by closely crowded dental ridges, which are about as wide as those of the anterior area. The denticles of these are quite fine. Of these ridges 22 are present in a line parallel to the ventral margin of the anterior part. The middle median portion is slightly concave and crossed by the nondenticulated decidedly curved continuations of the dental ridges of the anterior median portion, and fine incremental lines. The posterior median part bends rather abruptly downward to join the auricle. The interior is white. The junction of the anterior and median portion is marked by a rather strong cord. The middle median portion forms a slightly depressed roughened groove, at the basal termination of which the usual strong knob is situated. The auricle overlaps the posterior median portion decidedly and forms a rather strong shelf. The cordlike markings described for the exterior are also apparent on the inside. A strong, somewhat irregular curved blade extends from the inner side of the umbone two-thirds of the way toward the basal knob. The pallets consist of half a hollow cone; that is, the external portion is curved while the inner portion is almost flat. The cavity of the cone extends to the insertion of the stalk. The stalk is short and bears an expanded knob at its free end.

The type (Cat. No. 310975, U.S.N.M.) was collected in a piece of wood dredged during the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5252, in 28 fathoms on coral bottom off Linao Point, Gulf of Davao, Mindanao. It measures: Altitude, 2.2 mm.; length, 2.2 mm.; diameter, 2.2. The pallets measure: Length, 2.6 mm.; diameter, 1.3 mm., of which 1.2 mm. go to the stalk.

A lot of specimens from the same piece of wood are entered as Cat. No. 246127, U.S.N.M.

Subgenus TEREDOTHYRA Bartsch

1921. *Teredothyra* BARTSCH, Proc. Biol. Soc. Washington, vol. 34, p. 26.
1922. *Teredothyra* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 22.

In this subgenus the pallets are doubly cupped at the terminal portion.

Type.—*Teredo* (*Teredothyra*) *dominicensis* Bartsch.

TEREDO (TEREDOTHYRA) SMITHI, new species

SMITH'S TEREDO

Plate 53, figs. 6, 7; plate 56, fig. 4; plate 59, figs. 10, 11, 12

Shell small, subglobular, milk-white, the extreme anterior margin of the anterior part somewhat excavated and covered by a rather thick callus which is partly reflected over the outside. Posterior to this callus the anterior part is marked by ridges which radiate fan-shaped from the callus posteriorly. They are closely approximated anteriorly, the space between them widening posteriorly. Those on the first half of the shell are much more distantly spaced than the later ones, being about three times as far apart as the ridges themselves, while the later ones are about equal to the spaces that separate them at their posterior margin. The free borders of these ridges are finely denticulated. The spaces between the ridges are finely granulose. The anterior portion of the median part is crossed by 28 strong, denticulated ridges which are separated by mere impressed lines. Of these ridges, 21 are present in a straight line projected from the ventral border of the anterior part across the anterior portion of the median part. The individual denticles are doubly cusped at their free margin. The middle portion of the median part is concave and crossed by the attenuated continuations of the dental ridges which are here bent outward. The whole area is somewhat rough. The posterior portion of the middle part is about as wide as the anterior and median portions taken together, and is marked by numerous incremental lines and the feeble continuations of the stronger lines referred to for the middle part. The posterior part forms a rather conspicuous auricle which is separated from the posterior portion of the median part by a strongly impressed constriction. The auricle is usually badly eroded and is marked by concentric lines of growth paralleling the ventral margin. Interior bluish-white. The anterior part joins the middle part in a raised tumidity. The middle portion of the median part shows as a rough groove, at the ventral termination of which the strong knob is present. The posterior part extends over the posterior portion of the middle part as a strong shelf; the inner edge of this part is very heavy and the cavity behind it rather deep. The posterior portion when viewed from within is spatulate, the part that extends up to the umbone being the handle. There is a strong oblique irregular blade which springs from the underside of the umbone and extends three-fourths of the way from the umbone to the ventral knob. The pallet is very long and decidedly attenuated basally. There is a deep median fold on the outside which divides it into the two parts. There is also a deep excavation near the terminal lateral margin on the outside. Viewed from the inside the attenuated lateral wings of the expanded portion border the strong median rib which extends attenuatedly to the edge of the distal portion. The two lateral flaps of the distal expanded portion are decidedly concave. The calcareous margins, when viewed from the inside, extend as two pointed horns at the distal end, bearing the horny portion at their tips. There is a deep sinus at the distal end both above and below.

The type (Cat. No. 312919, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, in a piece of wood dredged at station 5266 off Matocot Point, western Luzon, in 100 to 135 fathoms on mud bottom. It measures: Height, 1.8 mm.; length, 1.5 mm.; diameter, 1.5 mm. Pallet measures: Length, 7.3 mm., of which 2.2 go to the stalk; diameter, 0.9 mm. Cat. No. 246128, U.S.N.M., contains a lot of specimens from the same piece of wood. Cat. No. 312920 contains a lot of specimens taken from a piece of wood dredged at station 5269 off Matocot Point, western Luzon, in 200 fathoms on fine sandy and pebbly bottom.

I take pleasure in naming this shipworm for Dr. Hugh M. Smith, formerly Commissioner of Fisheries and director of the *Albatross* Philippine Expedition.

TEREDO (TEREDOTHYRA) RADCLIFFEI, new species

RADCLIFFE'S SHIPWORM

Plate 53, figs. 11, 14; plate 56, fig. 5; plate 59, figs. 7, 8, 9

Shell small, thin, semitransluscent; the extreme anterior portion of the anterior part forms a narrow sinus which is covered by a rather thick callus that is partly reflected over the outside; the rest of the anterior part is covered by numerous slender, closely spaced denticulated ridges, of which 72 are present, and many more must have been lost when the apices of the umbones were eroded. These denticulated ridges become fused at the anterior margin and are separated on the early part of the shell by spaces about twice as wide as the ridges, and on the later portion by spaces about as wide as the ridges at their posterior extremity. Their free margin is finely denticulated; the anterior median area is very broad and marked by numerous ridges that bear strong denticles. Of these ridges 44 are present in a line projected across the area from the ventral border of the anterior part. The denticles are exceedingly fine. The middle portion of the median area is rather broad and crossed by the distantly spaced, outbent continuations of the dental ridges, which here lose their denticles, and fine lines between them. There are also two rather strong radiating lines present. The posterior portion of the middle part is about as wide as the anterior and middle portion combined, and is marked by the decidedly upbent continuations of the lines already referred to for the middle part. The posterior part forms a narrow auricle which is conspicuously constricted off where it joins the posterior portion of the median part. Interior of the shell bluish-white. A strong suture marks the junction of the anterior and middle part; there is a rough area marking the middle portion of the middle part bearing a conspicuous knob at its ventral margin. The posterior part extends over the posterior portion of the middle part as a shelf which is spatulate in shape, the narrowed handle extending up to the umbonal knob. There is a deep cavity behind this shelf. A slender thin blade extends from under the umbone obliquely ventrally through about two-thirds of the shell. The pallets are long and spatulate, the stalk occupying about two-fifths of the length. The expanded portion extends as a narrow wing down the two sides of the stalk; the distal portion of the pallet is deeply impressed to form the two pits, and there is an excavation on the two lateral margins where the calcareous and horny portions join. On the inside the pallets show the continuation of the stalk to almost the distal portion of the calcareous part, the lateral wings of the pallet being concave on each side. The horny portion has two lateral horns.

The type (Cat. No. 312921, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, from a piece of wood dredged at station 5252 off Linao Point, Gulf of Davao, Mindanao, in 28 fathoms on coral bottom. It measures: Height, 2.1 mm.; length, 2 mm.; diameter, 1.8 mm. The pallet measures: Length, 3.9 mm., of which 1.2 mm. go to the stalk; diameter of expanded blade, 0.6 mm.

I take pleasure in naming this mollusk for Mr. Lewis Radcliffe, Deputy Commissioner of Fisheries, who was a member of the scientific staff during the cruise of the *Albatross* in Philippine waters.

TEREDO (TEREDOTHYRA) TANONENSIS, new species

TANON SHIPWORM

Plate 54, fig. 7; plate 56, fig. 1; plate 59, figs. 1, 2, 3

Shell minute, milk-white, the anterior sinus of the anterior part is bordered by a rather thick callus which is reflected over the margin. From this margin strong denticulated ridges radiate fan-shaped over the rest of the anterior part. These ridges are closely approximated at the callus and become separated at their posterior end, on the early portion of the shell, by a space about four times as wide as the ridges. The last nine, however, are closely approximated at the distal portion. This seems to be a senescent character. The anterior portion of these ridges near the callus bear strong denticles, while the rest is very finely denticulated, the grooves separating the denticles passing down on both the dorsal and ventral margin of the ridges. The posterior termination of the anterior part forms almost an even arc. The anterior portion of the median part is crossed by strong dental ridges which are a little wider than those on the anterior part and very strongly denticulated. Of these ridges, 15 occur in a straight line parallel with the ventral margin of the anterior part. The denticles are somewhat spatulate in shape, the expanded portion being at the posterior margin, while the stalk portion occupies the anterior half. The median portion of the middle part is a slightly concave area almost as wide as the anterior portion of the median part. It is crossed by the feeble continuation of the dental ridges which here, however, are reduced to mere raised lines and without denticles. The posterior portion of the median part is about as wide as the anterior and middle portion combined, and is crossed by the continuation of the ridges just referred to in the middle portion, but these become decidedly enfeebled here. Posterior auricle narrow, almost clawlike, separated from the posterior portion of the median part by a strong constriction. The auricle is marked by rather strong, distantly spaced corrugations. Interior of shell bluish-white, the junction of the anterior and middle part marked by a somewhat irregular callus; the middle portion of the median part is marked by a rough slightly concave area which terminates ventrally in a strong knob. The posterior auricle extends over the posterior portion of the median part as a shelf with a conspicuous cavity behind it. It is translucent and shows the markings of the outside within. From under the strong umbone a strong, somewhat curved and twisted blade extends for about half the length of the shell. Pallets rather long, the stalk quite long, expanded toward the blade with a strong median groove on the outside which renders the pallet doubly cusped. The expanded blade bears a strong excavation immediately below the two lateral terminal horns. On the inside they are spoonshaped, showing the extension of the stalk prominently almost to the tip of the pallet. The extreme distal portion of the pallets bears thin membranes.

The type (Cat. No. 310964, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5189 off Pecador Island, Tenon Strait, in 300 fathoms on green mud bottom, bottom temperature 62.8°. It measures: Height, 2 mm.; length, 1.6 mm.; diameter, 1.8 mm. The pallets measure: Length, 4.2 mm., of which 2.6 go to the stalk; diameter blade, 0.9 mm. Cat. No. 310965, U.S.N.M., contains a lot of specimens taken from the same piece of wood, as well as a large piece of infected wood. Cat. No. 466131–A contains a specimen dredged at station 5243 off Pujada Bay, eastern Mindanao, in 218 fathoms on gray mud bottom, bottom temperature 63.6°.

UNGOTEREDO, new subgenus

Pallet of the shape of *Coeloteredo*, but with a calcareous portion in the blade which consists of two deep pits with a calcareous border separated by a deep median slit. The expanded portion reminds one, when viewed from the outside, of a goat's hoof with the toes pointing toward the stalk. It is not unlike *Teredothyra*, but the expanded blade is very short and broad. The shell is typically teredine. The posterior auricle extends over the posterior median portion forming a shallow shelf.

Type.—*Teredo* (*Ungoteredo*) matacotana Bartsch.

KEY TO THE SPECIES OF THE SUBGENUS OF UNGOTEREDO

- Pallets with a double transverse groove below the double cupped portion. **chamberlaini.**
- Pallets without a double transverse groove below the double cupped portion.
  - Pallets with a single transverse groove below the double cupped portion.
    - Cups separated by a deep median longitudinal cut ....**matocotana.**
    - Cups not separated by a deep median longitudinal cut.
      - Cups separated by an impressed line only ....**pujadana.**

TEREDO (UNGOTEREDO) MATOCOTANA, new species

MATOCOT SHIPWORM

Plate 53, figs. 8, 9; plate 56, fig. 2; plate 60, figs. 5, 6, 7

Shell small, anterior margin of the anterior part with a rather strong sinus which has a thin callus that is not reflected. This part is rather broad and bears strong denticulated ridges which take a sudden turn ventrally at the anterior margin and are then reflected across. They are badly eroded; the last seven only are left in good shape and these are separated at their posterior extremity by narrow grooves much less in width than the raised ridges. The anterior median portion is very broad and bears strong dental ridges which are separated by narrow incised lines. These ridges are a little less in width than those on the anterior part. The last eight only remain; the rest are stripped of their denticles. The denticles are doubly cusped, the anterior cusp being about twice as large as the posterior. The middle portion of the median part is rendered decidedly rough by irregular transverse wrinkles. The posterior portion of the middle part is about as wide as the middle portion and is crossed by lines of growth. The posterior part is very narrow and is separated from the posterior median part by a constriction. Interior bluish-white. The junction of the anterior and median part is marked by a raised thread. The posterior part is not differentiated from the median part within. The anterior portion of the middle part appears cancellated by transmitted light. A long twisted blade extends from under the strong umbonal knob about four-fifths of the distance across the cavity toward the strong ventral knob. The pallets have a rather long stalk which is somewhat roughened. The stalk as well as the basal portion of the expanded part is of pale horn color. The two cups are made up of white calcareous material and are separated on the outside by a deep broad channel. The inner border of these two cups is slender and somewhat perforated. It seems to be made up of bars which run parallel with the outer margin of the septum. The distal portion of the horn-colored part of the expanded pallet forms a slightly curved entire line. The sinus is in the calcareous cup wall only.

The type (Cat. No. 312930, U.S.N.M.) was found in a piece of wood dredged at station 5266 in 102 to 135 fathoms on mud bottom off Matocot Point, Luzon, by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition. It measures: Height 1.1 mm.; length, 1.3 mm.; diameter, 1.2 mm. The pallet measures: Length, 3 mm., of which 1.7 mm. go to the stalk; diameter, 1.5 mm.

TEREDO (UNGOTEREDO) CHAMBERLAINI, new species

CHAMBERLAIN'S SHIPWORM

Plate 54, figs. 1, 2; plate 57, fig. 5; plate 60, figs. 9, 10, 11

Shell minute, thin, semitransparent. The anterior sinus is narrow with a thin callus which is reflected over a small portion of the outside of the anterior part, free at the reflected edge. The anterior part is crossed by slender denticulated ridges which spread fan-shaped from the anterior callus where they are closely approximated posteriorly. At their posterior margin they are separated by spaces about as wide as the ridges. Of these ridges 50 are present in the type. These ridges are rather coarsely denticulated near the anterior margin and very finely so on their free edge throughout the rest of their length. The junction of the anterior and anterior median area forms an even curve. The anterior median area is moderately broad and marked by very slender denticulated ridges which are separated by mere impressed lines. These ridges are a little less wide than those on the anterior area. Twenty-eight of them occur in a straight line projected across the anterior median area from the ventral margin of the anterior part. The median portion of the middle part forms a slightly concave groove which extends from the umbones to the ventral margin. It bears in its middle a rounded cord and is crossed by the feeble continuations of the dental ridges which here make a decided curve and are not denticulated. The posterior portion of the middle part is about one and one-half times as wide as the anterior and median portions combined, and is crossed by numerous lines of growth which lend to it a somewhat corrugated aspect. The posterior part forms a very strong, broadly expanded auricle which is marked from the posterior median portion by a strong constriction. It is rendered somewhat fluted by incremental lines. There is a strong knob at the junction of the median and posterior part at the ventral margin. Interior bluish-white. The suture of the anterior and median part marked by a raised line. The middle portion of the median part forms a somewhat rough depressed groove which extends from the umbone to the ventral margin where it terminates in an elongated knob. The posterior part projects over the posterior median portion as a narrow shelf with a shallow cavity behind it. There is a rather long slender oblique somewhat twisted blade which extends two-thirds of the distance from the umbone to the ventral knob. The pallets are paddle-shaped, the stalk being expanded basally with two constrictions in it that give it a somewhat nodulose aspect, decidedly contracted where it joins the expanded portion of the pallet. The outside of the base of the expanded portion is lunate and, like the stalk, of a translucent horn color. This part appears to form a cup in which two calcareous cups, which resemble the horn portion of the hoofs of a sheep, are placed, with the toe end extending into the cup before mentioned. These two elements are separated by a deep groove. The inside of the expanded portion is triangular in shape and the distal margin has a moderately deep cut in its middle.

The type (Cat. No. 312922, U.S.N.M.) comes from a piece of wood collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, at station 5252 off Linao Point, Gulf of Davao, Mindanao in 28 fathoms on coral bottom. It measures: Height, 1.4 mm.; length, 1.3 mm.; diameter, 1.2 mm. Pallet measures: Length, 1.5 mm., of which 0.8 go to the stalk; diameter, 0.7 mm. The species is named for the late Frederick M. Chamberlain, naturalist of the *Albatross* during her Philippine cruise.

TEREDO (UNGOTEREDO) PUJADANA, new species

PUJADA SHIPWORM

Plate 54, figs. 8, 10; plate 57, fig. 3; plate 60, figs. 1, 2, 3

Shell small, subglobular, the anterior part with a moderately broad sinus which is bordered by a narrow smooth callus. Radiating from this callus are strong broad denticulated ridges which equal those of the anterior median portion in strength. Those on the early part of the shell have been worn away and only about a dozen near the ventral margin remain. These are separated here by grooves a little narrower than the ridges at their posterior margin, and they are finely denticulated at the free border, the grooves demarking the denticles passing down both dorsally and ventrally over the ridge. The anterior median portion is exceedingly broad and is marked by 31 dental ridges in a straight line projected from the ventral margin of the anterior part. All but the anterior eight are badly worn; these have rather broad denticles. The median middle portion is narrow and slightly concave and here is where the shell terminates. The posterior median and auricular portion are not present and have probably been eroded. Interior showing the external sculpture by transmitted light. The anterior and median part meet in a straight suture. There is no indication of a posterior auricle on the inside. There is a strong knob on the anterior median portion and a long, somewhat twisted and sinuous blade extending from under the umbone. The pallets are rather large, paddle-shaped; the stalk is slender, twisted, and slightly nodulose basally. On the outside the basal expanded portion is lunate; a strong deep groove separates this part from the doubly cup-shaped distal area, the two cups being separated by a deep groove. On the inside the pallets are slightly concave, marked by numerous fine incremental lines with a mere indication of a median sinus at the distal end.

The type (Cat. No. 246131, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, in a piece of wood dredged at station 5243 in Pujada Bay, eastern Mindanao in 218 fathoms on gray mud, bottom temperature 63.6°. It measures: Height, 1.4 mm.; length, 1.6 mm.; diameter, 1.4 mm. The pallet measures: Length, 3 mm., of which 1.9 mm. go to the stalk; diameter, 1.6 mm.

Subgenus LYRODUS Gould

1870. *Lyrodus* GOULD, Invert. Mass., p. 34.
1922. *Lyrodus* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 24.

In this subgenus the terminal portion is not cupped, but ends in two lateral forks, covered with a periostracum.

Type.—*Teredo* (*Lyrodus*) *chlorotica* Gould.

TEREDO LYRODUS LINAOANA, new species

LINAO SHIPWORM

Plate 55, figs. 1, 4; plate 57, fig. 6; plate 59, figs. 4, 5, 6

Shell small, subglobular, white. The extreme anterior portion of the anterior part forms a shallow sinus and is covered by a rather thick callus which is reflected partly over the outer part of the anterior area. Posterior to this callus the anterior part is crossed by slender ridges which radiate fan shaped from the callus posteriorly, being closely approximated; in fact, fused at the callus and separated by spaces a little wider than the ridges at their posterior margin. Of these ridges there are 51 in the type and many have been lost by the erosion at the umbone. These ridges are very finely denticulated at their free margin. The anterior portion of the median area is narrow and marked by slender denticulated ridges which are much narrower than those on the anterior portion and are separated by mere incised lines only. Of these ridges, 26 occur in a straight line across the anterior portion of the median area parallel to the ventral margin of the anterior part. The individual denticles on these ridges are exceedingly fine and closely spaced. The junction of the anterior portion and the anterior portion of the median part forms a somewhat sinuous line. The middle portion of the median part is almost as wide as the anterior portion and is crossed by the continuation of the decidedly flexed dental ridges which here are without denticles. These appear as a series of distantly spaced raised threads. The posterior portion of the median part is considerably wider than the anterior and middle portion of the median part combined, and is crossed by the continuation of the strong lines that cross the middle median portion, but here these threads become decidedly upturned. There is a strong constriction between the posterior termination of the median part and the posterior auricle. The posterior auricle is large and projects prominently and is marked by a series of ridges that give it a somewhat corrugated appearance. Interior bluish-white. The junction of the anterior and median part is indicated by a strongly impressed straight line. The median part forms a roughened area which extends from the umbone to the ventral margin where it terminates in a strong knob. The posterior portion extends over the posterior median portion as a shelf with a shallow cavity behind its anterior edge. This shelf extends from the umbone to the angular junction at the ventral margin of the auricle and the median part. The umbone forms a strong knob from the basal part of which a strong oblique somewhat twisted blade extends toward the ventral knob. Pallets rather long and slender with a narrow spatulate calcareous shaft beyond the stalk covered with a brown periostracum which terminates distally in a calcareous knob.

The type (Cat. No. 312917, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, from a piece of wood dredged at station 5252 off Linao Point, Gulf of Davao, Mindanao, in 28 fathoms on coral bottom. The type measures: Height, 2 mm.; length, 2 mm.; diameter, 1.8 mm. The pallet measures: Length, 2.6, of which 1.2 go to the stalk; diameter of blade, 0.3 mm. Cat. No. 312918, U.S.N.M., contains an additional lot of specimens from the same piece of wood. Cat. No. 246131–B, U.S.N.M., contains a specimen collected at station 5243 in Pujada Bay, eastern Mindanao, in 218 fathoms on green mud bottom, bottom temperature 63.6°.

Subgenus PSILOTEREDO Bartsch

1922. *Psiloteredo* BARTSCH, Bull. 122, U. S. Nat. Mus., p. 36.

In this subgenus the auricle fuses with the posterior median portion on the inside in such a manner that no shelf projects. In fact, in some of the species it is difficult to note even a suture. The pallets are spoon shaped, with the outer distal portion slightly excavated.

Type.—*Teredo dilatata* Stimpson.

?TEREDO (PSILOTEREDO?) ESCARCEOANA, new species

ESCARCEO SHIPWORM

Plate 54, figs. 3, 9; plate 57, fig. 4

Shell small, semitransluscent, bluish-white. Anterior portion eroded at the umbone, with a narrow callus at that part of the anterior margin which is left uneroded. From this slight callus the ridges radiate backward in a fan-shaped manner. At their posterior margin they are about as wide as the spaces that separate them. Of these ridges, which are very finely denticulated at their free margin, 21 are left in the type. A large number must have been eroded at the umbone. The junction of the anterior part with the anterior margin of the median part forms a shallow curve. The anterior portion of the median part is marked by slender denticulated ridges which are separated by deep narrow grooves. Of these ridges 17 are present in a straight line across the anterior median part from the basal margin of the anterior part. The individual denticles of these ridges bear doubly denticulated cusps, the anterior denticle being about twice as large as the posterior. The middle portion of the median part is moderately broad, the anterior half of which is slightly convex, while the posterior half is slightly concave; both are crossed by the continuation of the dental ridges of the anterior portion which here take a decided turn, become much enfeebled and edentulous. The posterior portion of the median part is about as wide as the anterior and middle portion combined. It passes in a gentle depression directly into the posterior auricle and bears a continuation of the fluted wavy sculpture of this part. The posterior auricle is moderately large and poorly differentiated from the posterior portion of the median part. It is marked by rather regularly disposed riblike raised wavy elements which are parallel with its ventral margin in disposition. Interior bluish-white. The anterior and median portion are joined in a distinct raised thread; the middle median portion is slightly roughened and terminates ventrally in a strong rounded knob; the auricle fuses with the posterior median portion without any demarkation or shelving; it is for that reason that I am placing this shell in the subgenus *Psiloteredo,* with a question mark; the umbones are strong and from their ventral margin an oblique somewhat irregular blade extends parallel with the middle area through four-fifths the length of the shell. The pallets of this species have not been found, and it will require their presence before we can give a fixed systematic status to this species.

The type (Cat. No. 312931, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, in a piece of wood dredged at station 5294 off Escarceo Point, northern Mindoro, in 244 fathoms on sand and pebbly bottom; bottom temperature, 48.4°. It measures: Height, 2 mm.; length, 2.1 mm.; diameter, 2 mm. Another specimen (Cat. No. 365932) comes from station 5294 of Escarceo Point, Northern Mindoro, in 244 fathoms on sand and pebbles; bottom temperature, 48.4°.

Genus EOTEREDO Bartsch

1923. *Eoteredo* Bartsch, Proc. Biol. Soc. Wash., vol. 36, p. 98.

Blade not projecting from the under side of the inside of the umbones, but attached to the middle of the broad shelf that constitutes the inward projection of the posterior part of the shell. Pallets unknown.

Type.—*Eoteredo philippinensis* Bartsch.

All the shipworms so far examined have the blade extending from the inside of the umbone. The present form marks an entirely different type of departure, for here it is attached to the middle of the shelf formed by the inward projection of the auricle. I deem this sufficiently distinct to merit generic separation. It is unfortunate not to have the pallets of this species, which would at once show to which of the three genera that I have recognized in my monograph the present genus is most nearly related.

EOTEREDO PHILIPPINENSIS Bartsch

PHILIPPINE EOTEREDO

Plate 54, figs. 4–6; plate 57, fig. 7

1923. *Eoteredo philippinensis* Bartsch, Proc. Biol. Soc. Wash., vol. 36, pp. 98, 99.

Shell subglobular, yellowish white, with the posterior portion forming the merest trace of an auricle on the outside. Umbones eroded even in very young specimens. The anterior part very broad with its anterior portion terminating in a somewhat curved sinus, the edge of which is slightly reflected posteriorly as a thin callus. The rest of the anterior part is marked by dental ridges, which make an even open curve from the anterior margin ventrally, then posteriorly to their posterior termination, where they join with the dental ridges of the posterior median part. Eighty-two of these ridges remain in the type and a good many more must have been eroded at the umbone. The ridges of this anterior portion are triangular with their free border finely, evenly serrated. The posterior median portion covers two-thirds of the median part, and is marked by dental ridges which join those of the anterior part at right angles. The denticles here are broad and sharply cusped. The median middle portion is about one-eighth the width of the posterior median portion and is marked by curved rough lines of growth. The posterior median portion is about as wide as the middle median portion and marked by feebler continuations of the lines of growth than those that characterize the middle median portion. The posterior part, or auricle constitutes a very small projection when viewed from the outside, the merest indication of a claw, as it were. Interior bluish-white. The junction of the anterior and median portion is marked by a roughened suture. The umbonal and ventral knobs are prominent. The erosion of the posterior umbonal region, even in young specimens, forms an opening in this region to the inside which is anteriorly bordered by a strong shelf that extends from the umbone to the posterior ventral margin. From the under side of the middle of this shelf the broad blade bends down toward the ventral knob. It is the peculiar position of the blade in this instance which has prompted me to give to this form a generic designation. Pallets unknown.

The type (Cat. No. 311281, U.S.N.M.) comes from a piece of wood dredged at United States Bureau of Fisheries Station 5243, off Uanivan Island Pujada Bay, Southeast Mindanao in 218 fathoms on gray mud bottom. The type, the largest specimen, measures: Height, 4.2 mm.; length, 3.9 mm.; thickness, 4.2 mm.

Cat. No. 311282, U.S.N.M., contains additional specimens which were obtained at the same station.

?TEREDO (subgenus?) MINDOROANA, new species

MINDORO SHIPWORM

Plate 55, figs. 3, 5; plate 57, fig. 1

Shell of medium size, subglobular, the anterior area with a rather large sinus which is bordered by a slender callus that is reflected over the anterior area at the edge. From this callus the dental ridges pass first a little ventrally, then across the anterior area. They are closely approximated at their anterior margin and separated by spaces a little wider than the ridges at the posterior edge of the later part, and fully twice if not three times as wide on the early part. Of these ridges 56 are present in the type, and many more have been eroded at the umbone. They are very finely denticulated at their free margin. The anterior median portion is very broad and marked by very broad denticulated ridges which are separated by very deep narrow channels. Of these ridges 40 occur in a line projected across this area from the ventral margin of the anterior part. The individual denticles are doubly cusped, the anterior one being about twice as wide as the posterior. The middle portion of the median part is slightly concave and marked by the continuations of the dental ridges of the anterior portion which are here bent and edentulous. They render this portion rather rough in appearance. The posterior portion is about as wide as the anterior portion of the middle part and is distinguished from the posterior auricle by a deep constriction. It is marked by concentric lines of growth which are parallel with its ventral margin in curving. The posterior auricle is large and projects like a strong claw. It is marked by conspicuous wavelike corrugations which agree with the ventral margin in disposition. Interior bluish-white. A conspicuous cord is present on the suture of the anterior and median part. The posterior part is projected decidedly over the posterior portion of the median part, almost half extending into the cavity of the shell. This part is ear-shaped and its inner border is free and leaves a shallow cavity behind it. It terminates dorsally in a strengthened cord which separates the expanded portion conspicuously from the narrowed dorsal border that extends to the umbone. The inside, like the outside, is marked by concentric corrugations. A strong broad blade extends from under the heavy umbone ventrally. It is broken so that we can not tell the limit of its extent.

The type (Cat. No. 312933, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, from a piece of wood dredged at station 5294, in 244 fathoms on sand and pebble bottom, bottom temperature 48.4°, off Escarceo point. Northern Mindoro. No pallets were found. We are therefore unable to assign a definite systematic position to this species. Its shell characters distinguished it from any of the other known forms, and we add it for completeness of record. The type measures: Height, 3.8 mm. (it should be here stated that the ventral portion of the valve is broken—a complete specimen would probably measure 4.2 mm.); length, 5 mm.; diameter of single valve, 2.4 mm.

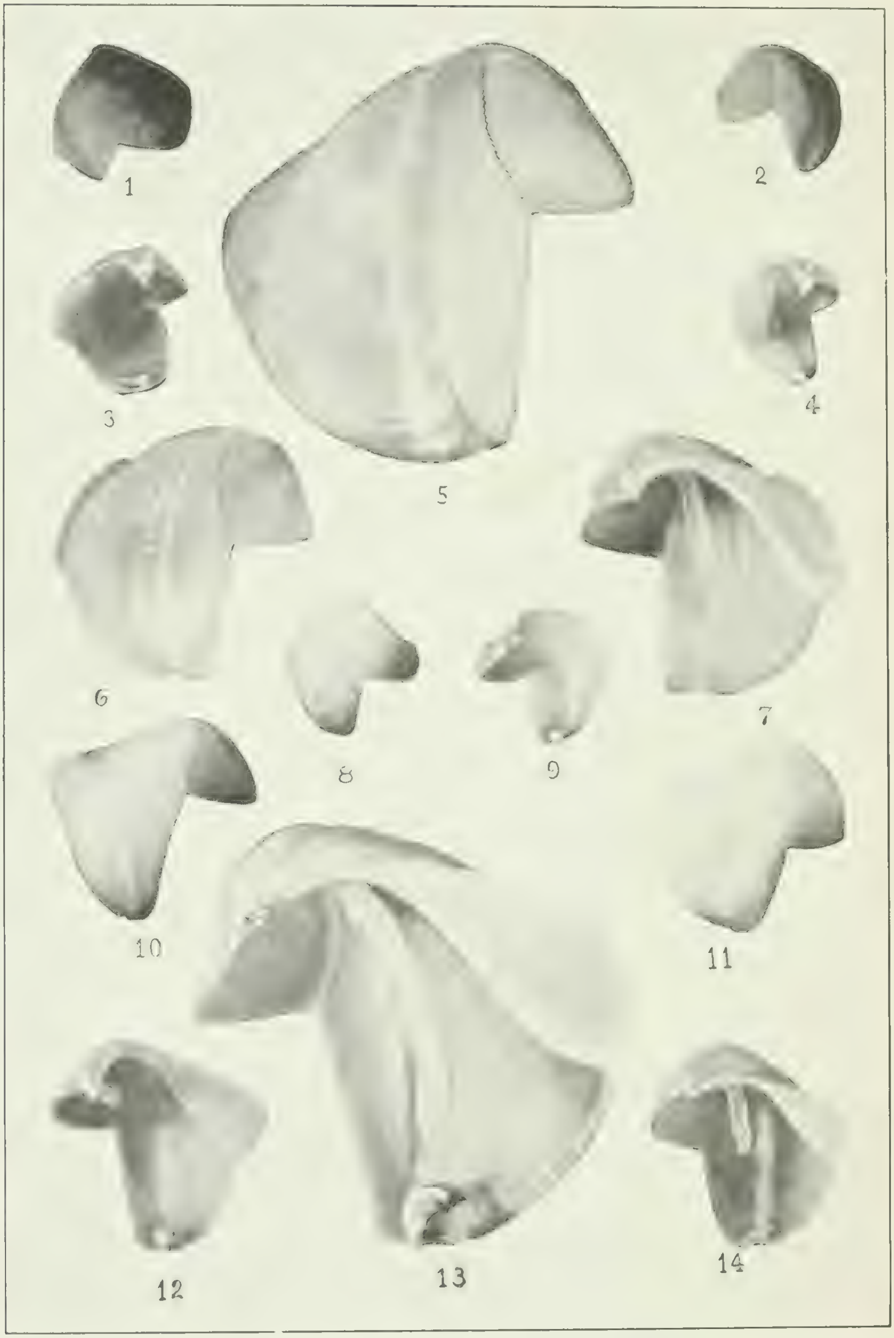
? TEREDO (subgenus?) LUZONENSIS, new species

LUZON SHIPWORM

Plate 55, figs. 2, 6; plate 57, fig. 2

Shell moderately large, flesh colored with a pinkish flush, the anterior area with a sinus that is bordered with a strong callus which is reflected over part of the anterior area. From the edge of the callus the denticulated ridges spread fan-shaped posteriorly. They are closely approximated at the anterior edge, and the early ones are about twice as far apart as the ridges at their posterior termination, while the later are separated by spaces no wider than the ridges. These ridges are finely denticulated at their free border. Fifty-nine of these are present in the type. The junction of the anterior and posterior median area forms an even curve. The anterior portion of the median area is marked by rather strong dental ridges which are separated by very deep, narrow grooves. Of these ridges 32 are present in a line projected across this area from the ventral border of the anterior part. The denticles borne on these ridges are doubly cusped and where they have been eroded they leave a basal area which is separated into a wider anterior portion and a narrower posterior raised line. The middle portion of the median part consists of an anterior convex portion which is crossed by the continuations of the denticular ridges which are reflected across it in an open arc but do not bear denticles here, and a slightly concave posterior portion about as wide as the anterior which is crossed by feebler continuations of these lines with finer elements between them. The posterior median part is considerably wider than the anterior and middle portion of the median part, and is marked by fine curved lines which are in reality the continuations of those of the middle part. The posterior part is distinguished from the median part by a profound constriction. It forms an immense auricle which is very high and which is marked by feeble concentric lines which coincide with its basal margin. The junction of the anterior and median part is marked by a tumid area. Interior bluish white, the middle portion is rather roughened and terminates ventrally in a very strong knob. The posterior part is wing-shaped, very broadly expanded and placed upon the posterior portion of the median part in such a way that it projects over it as a decided shelf which is very thick at its free border and contains a large cavity behind it that extends to the ventral margin. The umbonal portion, that is, about one-fourth of the length of the posterior part, is narrow and very much thickened, while the rest is very broadly expanded and concave, and marked by wavelike corrugations which coincide with the ventral margin in disposition. There is a strong blade which extends obliquely from over the umbone toward the ventral knob. The pallet is unknown. We are therefore unable to give this form subgeneric or even generic designation. The shell, however, is so characteristic that, for the sake of completeness, we felt that the species must be recognized.

The type (Cat. No. 311063, U.S.N.M.) was collected by the United States Bureau of Fisheries Steamer *Albatross* Philippine Expedition, from a piece of wood dredged at station 5269 off Matocot Point, western Luzon, in 220 fathoms on fine sand and pebbly bottom. It measures: Height, 6.3 mm.; length, 6.5 mm.; diameter of half shell 3 mm. Cat. No. 312934, U.S.N.M., contains another valve taken from the same piece of wood.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SHIPWORMS OF THE PHILIPPINE ISLANDS

FOR EXPLANATION OF PLATE SEE PAGE 555

EXPLANATION OF PLATES

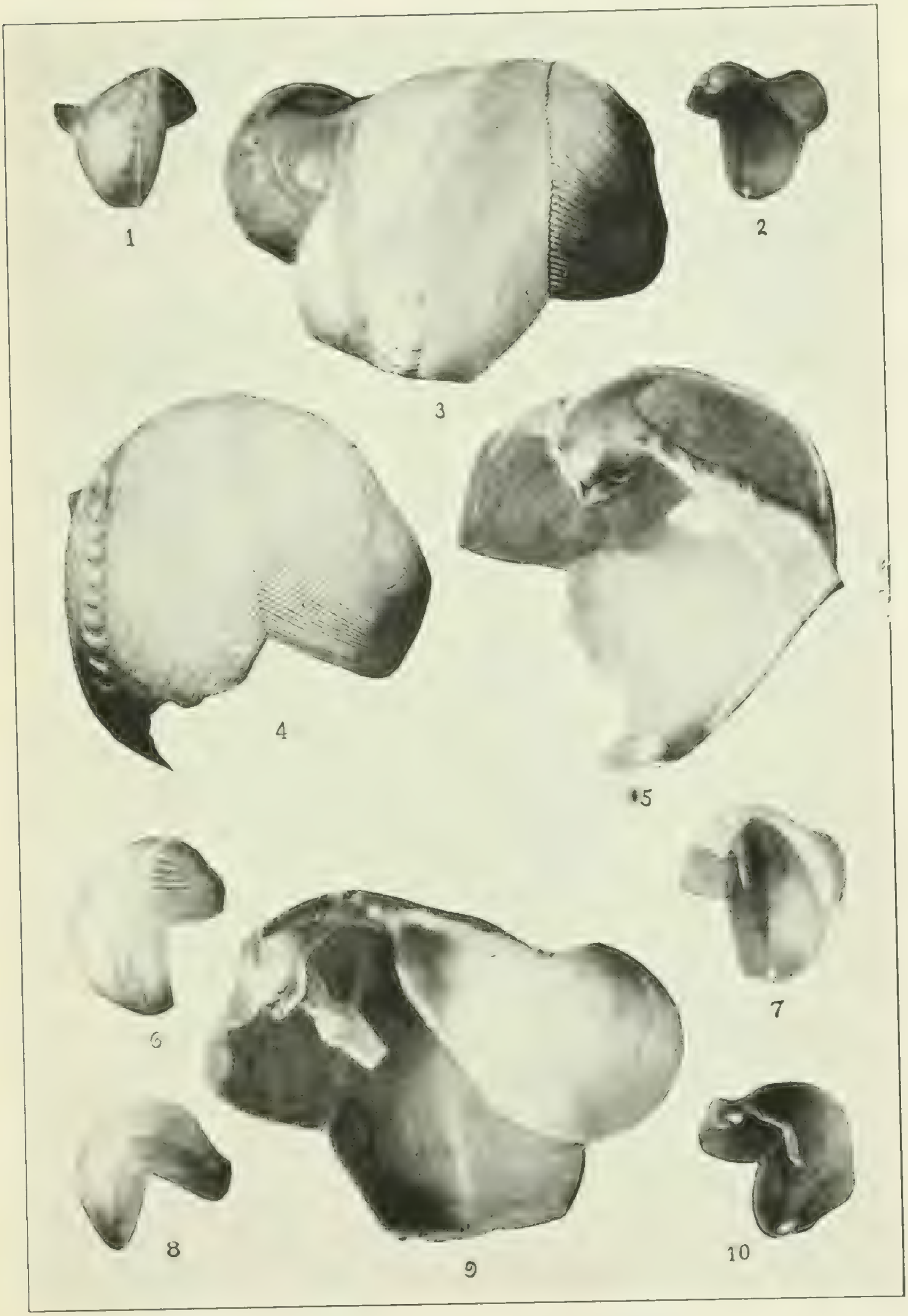
All figures of the shell have been given the same enlargement. This is also true of the detail of the shell sculpture, but this is of much greater magnification than that of the shell.

PLATE 53

FIG. 1. *Bankia* (*Bankia*) *philippinensis*.
2. *Bankia* (*Bankiella*) *davaoensis*.
3. *Bankia* (*Bankia*) *philippinensis*.
4. *Bankia* (*Bankiella*) *davaoensis*.
5. *Bankia* (*Neobankia*) *johnsoni*.
6. *Teredo* (*Teredothyra*) *smithi*.
7. *Teredo* (*Teredothyra*) *smithi*.
8. *Teredo* (*Ungoteredo*) *matocotana*.
9. *Teredo* (*Ungoteredo*) *matocotana*.
10. *Teredo* (*Coeloteredo*) *mindanensis*.
11. *Teredo* (*Teredothyra*) *radcliffei*.
12. *Teredo* (*Coeloteredo*) *mindanensis*.
13. *Bankia* (*Neobankia*) *johnsoni*.
14. *Teredo* (*Teredothyra*) *radcliffei*.

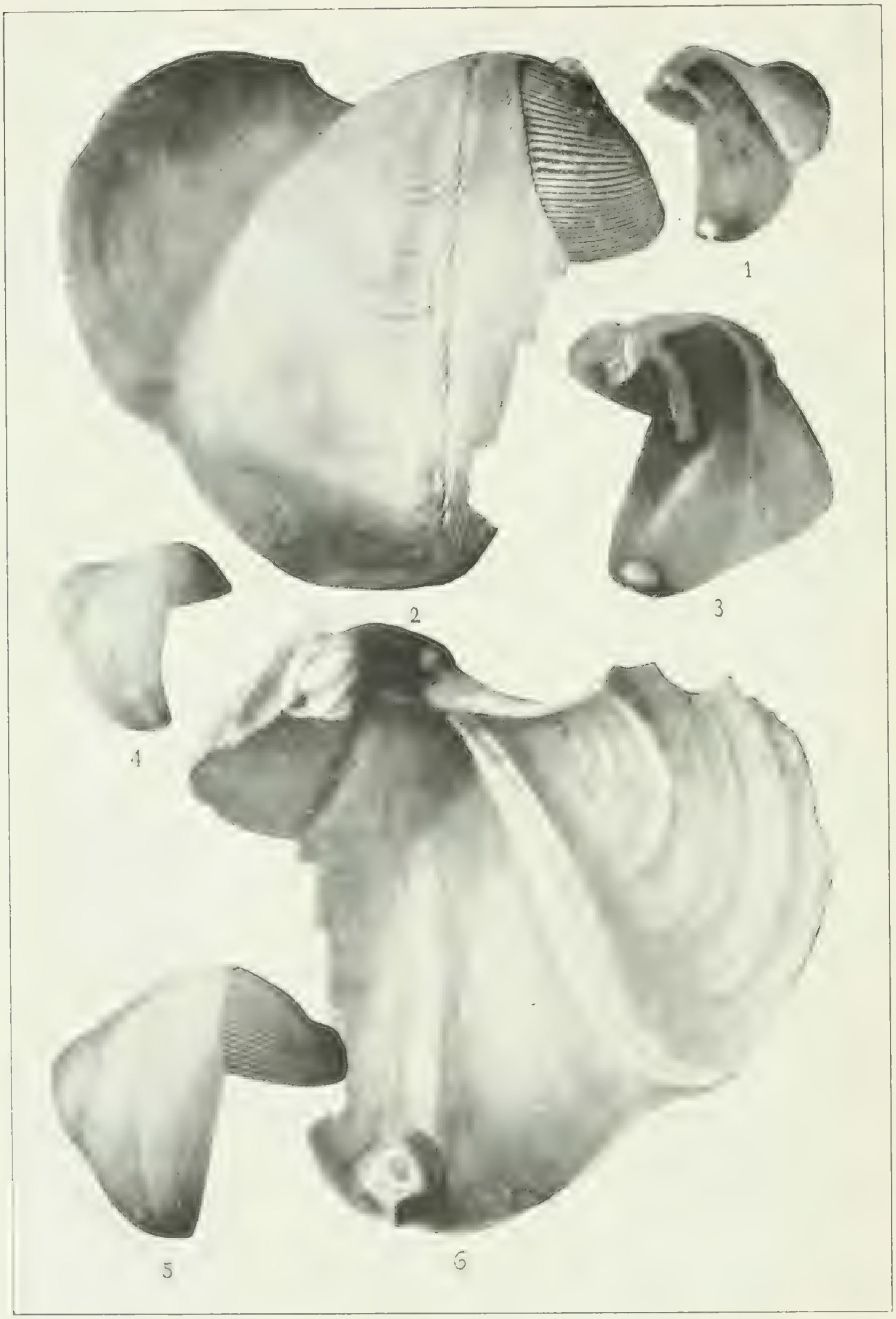
PLATE 54

FIG. 1. *Teredo (Ungoteredo) chamberlaini.*
2. *Teredo (Ungoteredo) chamberlaini.*
3. *Teredo (Psiloteredo?) escarceoana.*
4. *Eoteredo philippinensis.*
5. *Eoteredo philippinensis.*
6. *Eoteredo phillippinensis.*
7. *Teredo (Teredothyra) tanonensis.*
8. *Teredo (Ungoteredo) pujadana.*
9. *Teredo (Psiloteredo?) escarceoana.*
10. *Teredo (Ungoteredo) pujadana.*



SHIPWORMS OF THE PHILIPPINE ISLANDS

FOR EXPLANATION OF PLATE SEE PAGE 556



SHIPWORMS OF THE PHILIPPINE ISLANDS

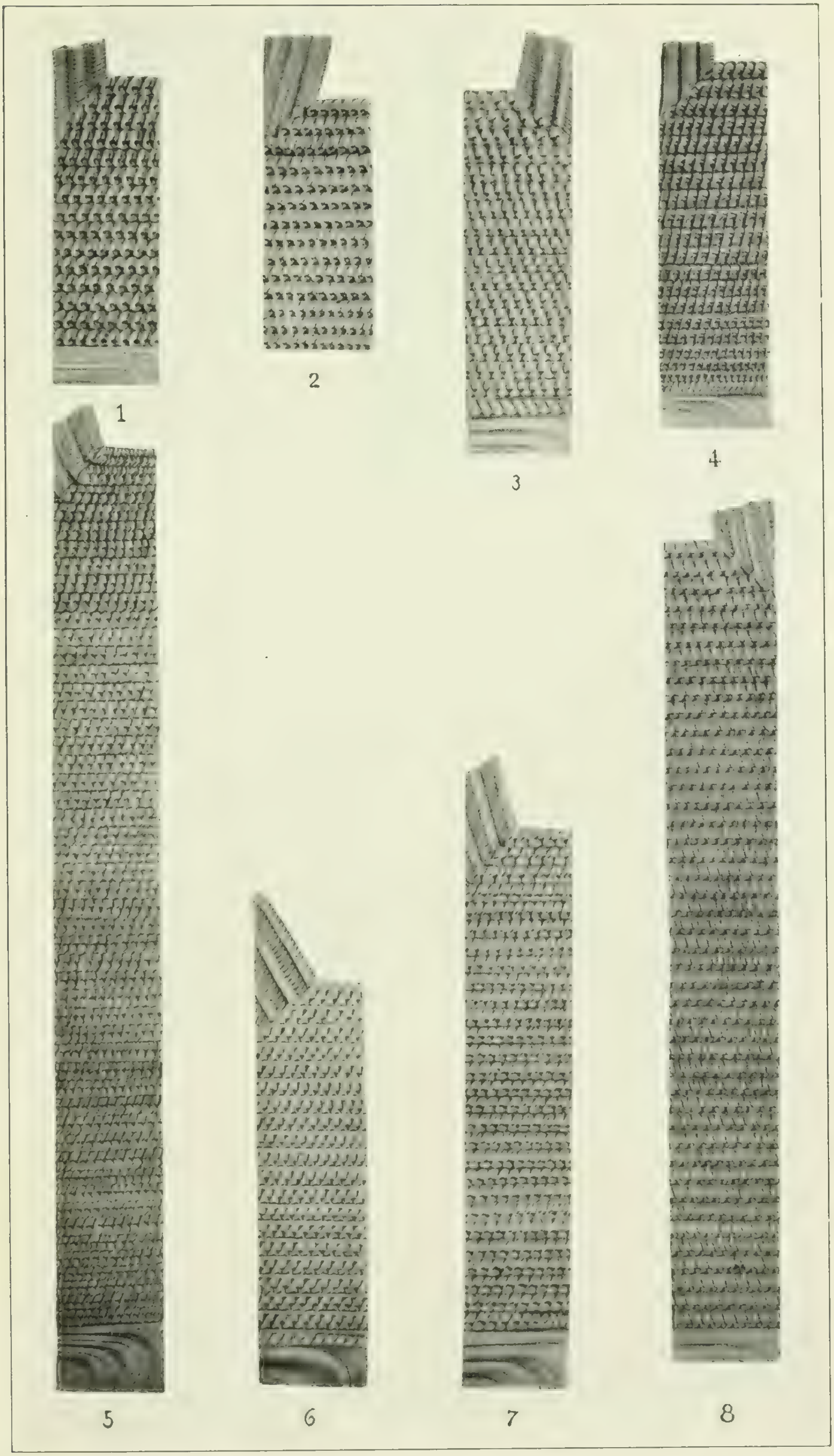
FOR EXPLANATION OF PLATE SEE PAGE 557

PLATE 55

FIG. 1. *Teredo* (*Lyrodus*) *linaoana.*
2. ?*Teredo* (subgenus?) *luzonensis.*
3. ?*Teredo* (subgenus?) *mindoroana.*
4. *Teredo* (*Lyrodus*) *linaoana.*
5. ?*Teredo* (subgenus?) *mindoroana.*
6. ?*Teredo* (subgenus?) *luzonensis.*

PLATE 56

FIG. 1. *Teredo (Teredothyra) tanonensis.*
2. *Teredo (Ungoteredo) matocotana.*
3. *Bankia (Bankiella) davaoensis.*
4. *Teredo (Teredothyra) smithi.*
5. *Teredo (Teredothyra) radcliffei.*
6. *Teredo (Coeloteredo) mindanensis.*
7. *Bankia (Neobankia) johnsoni.*
8. *Bankia (Bankia) philippinensis.*



SHIPWORMS OF THE PHILIPPINE ISLANDS

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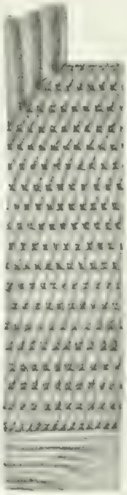
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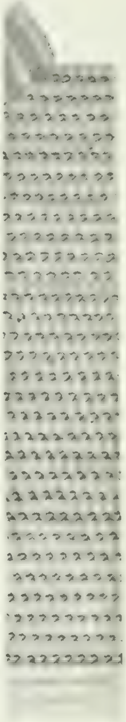
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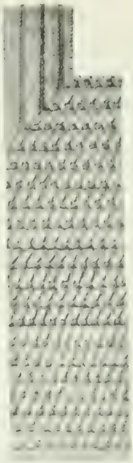
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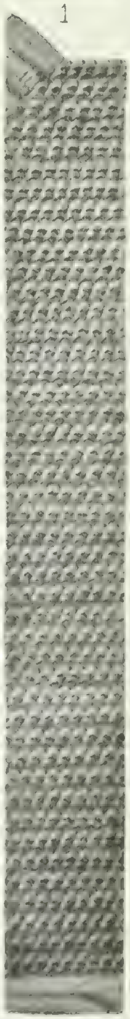
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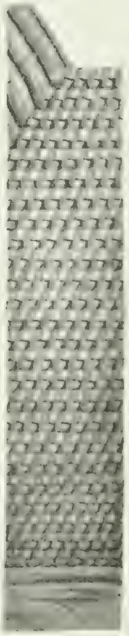
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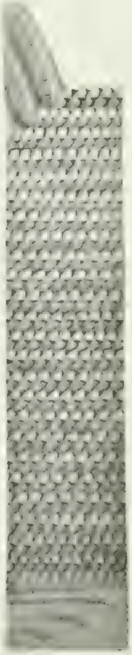
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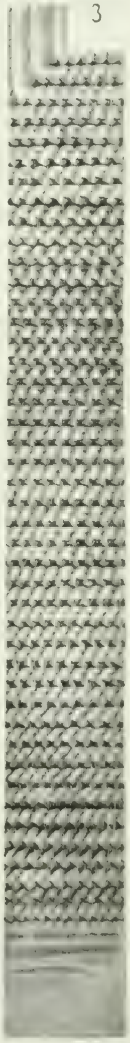
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SHIPWORMS OF THE PHILIPPINE ISLANDS

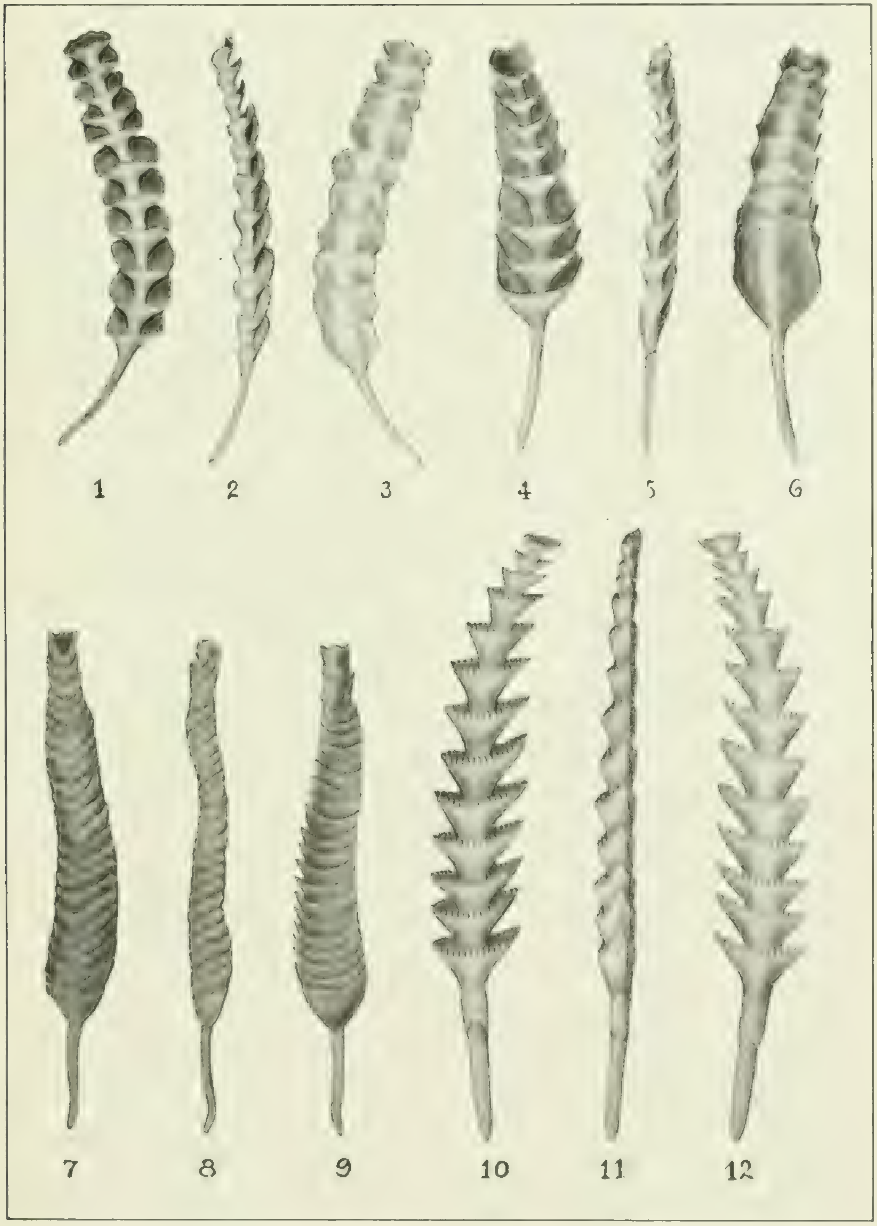
FOR EXPLANATION OF PLATE SEE PAGE 559

PLATE 57

FIG. 1. *?Teredo* (subgenus?) *mindoroana.*
2. *?Teredo* (subgenus?) *luzonensis.*
3. *Teredo* (*Ungoteredo*) *pujadana.*
4. *Teredo* (*Psiloteredo*) *escarceoana.*
5. *Teredo* (*Ungoteredo*) *chamberlaini.*
6. *Teredo* (*Lyrodus*) *linaoana.*
7. *Eoteredo philippinensis.*

Plate 58

Fig. 1. *Bankia* (*Neobankia*) *barthelowi.*
2. *Bankia* (*Neobankia*) *barthelowi.*
3. *Bankia* (*Neobankia*) *barthelowi.*
4. *Bankia* (*Bankiella*) *davaoensis.*
5. *Bankia* (*Bankiella*) *davaoensis.*
6. *Bankia* (*Bankiella*) *davaoensis.*
7. *Bankia* (*Bankia*) *philippinensis.*
8. *Bankia* (*Bankia*) *philippinensis.*
9. *Bankia* (*Bankia*) *philippinensis.*
10. *Bankia* (*Neobankia*) *johnsoni.*
11. *Bankia* (*Neobankia*) *johnsoni.*
12. *Bankia* (*Neobankia*) *johnsoni.*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SHIPWORMS OF THE PHILIPPINE ISLANDS

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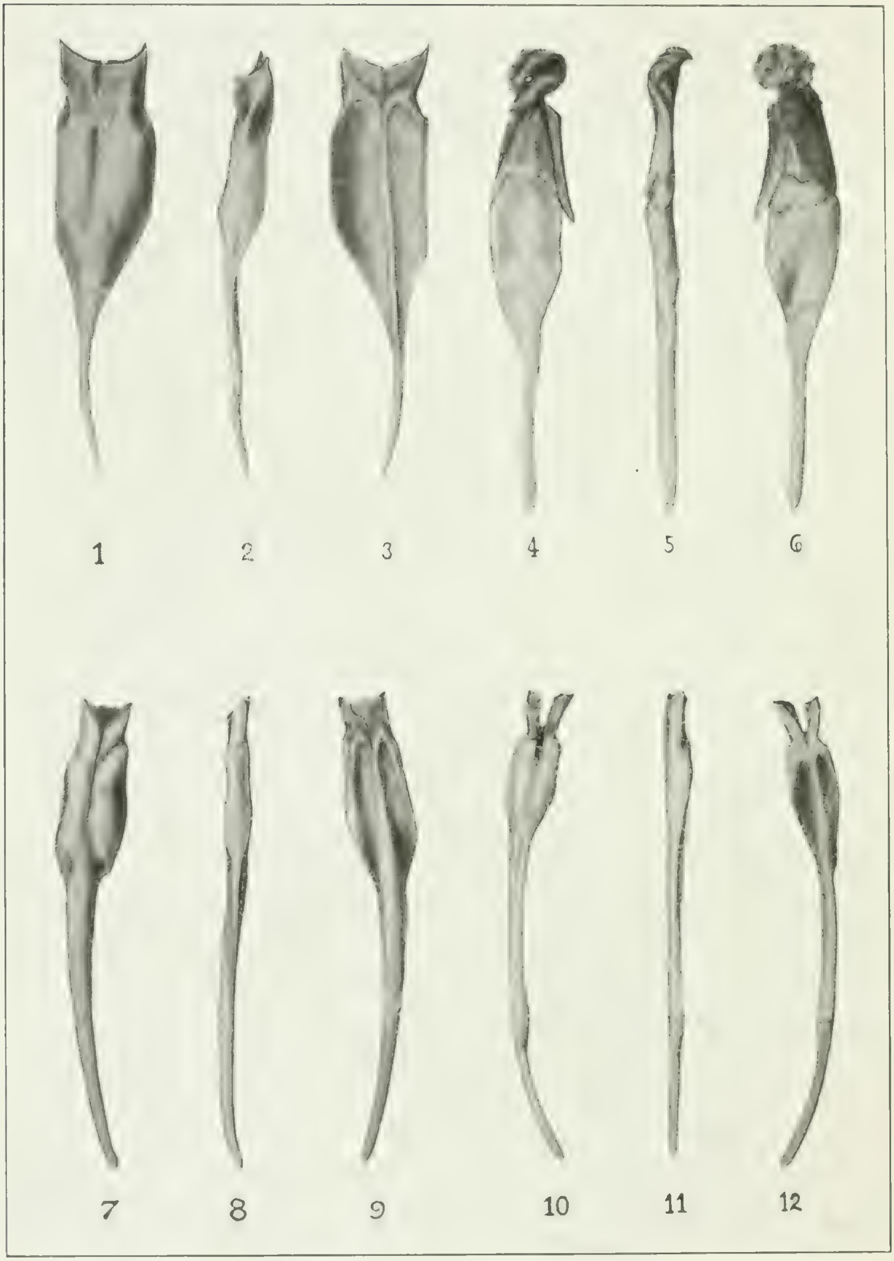
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SHIPWORMS OF THE PHILIPPINE ISLANDS

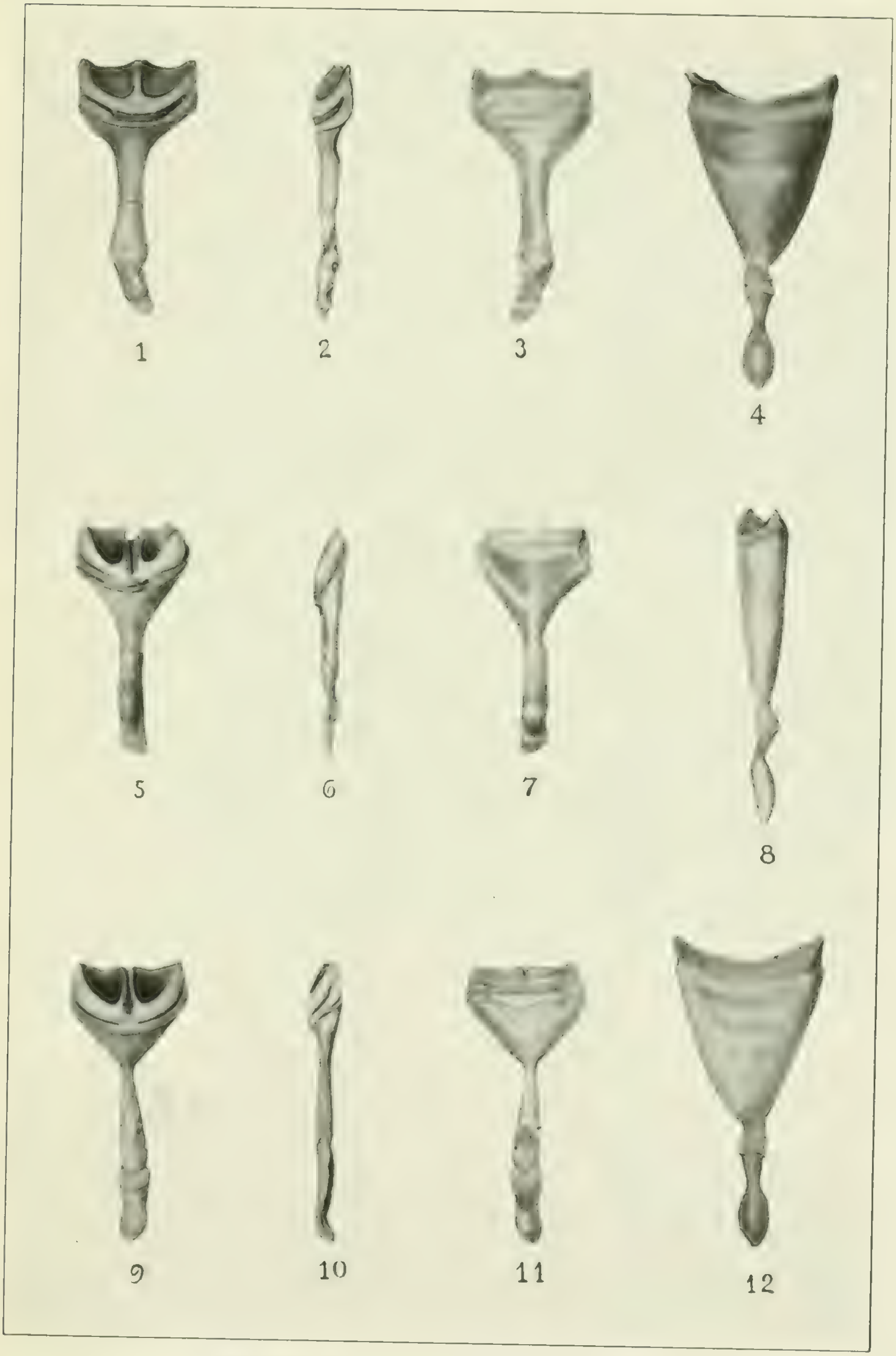
FOR EXPLANATION OF PLATE SEE PAGE 561

Plate 59

Fig. 1. *Teredo* (*Teredothyra*) *tanonensis*.
2. *Teredo* (*Teredothyra*) *tanonensis*.
3. *Teredo* (*Teredothyra*) *tanonensis*.
4. *Teredo* (*Lyrodus*) *linaoana*.
5. *Teredo* (*Lyrodus*) *linaoana*.
6. *Teredo* (*Lyrodus*) *linaoana*.
7. *Teredo* (*Toredothyra*) *radcliffei*.
8. *Teredo* (*Teredothyra*) *radcliffei*.
9. *Teredo* (*Teredothyra*) *radcliffei*.
10. *Teredo* (*Teredothyra*) *smithi*.
11. *Teredo* (*Teredothyra*) *smithi*.
12. *Teredo* (*Teredothyra*) *smithi*.

Plate 60

Fig. 1. *Teredo* (*Ungoteredo*) *pujadana.*
2. *Teredo* (*Ungoteredo*) *pujadana.*
3. *Teredo* (*Ungoteredo*) *pujadana.*
4. *Teredo* (*Coeloteredo*) *mindanensis.*
5. *Teredo* (*Ungoteredo*) *matocotana.*
6. *Teredo* (*Ungoteredo*) *matocotana.*
7. *Teredo* (*Ungoteredo*) *motocotana.*
8. *Teredo* (*Coeloteredo*) *mindanensis.*
9. *Teredo* (*Ungoteredo*) *chamberlaini.*
10. *Teredo* (*Ungoteredo*) *chamberlaini.*
11. *Teredo* (*Ungoteredo*) *chamberlaini.*
12. *Teredo* (*Coeloteredo*) *mindanensis.*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SHIPWORMS OF THE PHILIPPINE ISLANDS

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